THE OVERARM THROW

An analysis of the basic skill and

a suggested approach to teaching.

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INTRODUCTION

The overarm throw is a fundamental skill and is the basis upon which many games are built. Most children acquire the skill naturally but a minority have difficulty learning it and some never master it. It is possible that instruction given at the right time and in an appropriate manner would help the minority to a more accomplished level of performance of the skill. With this in mind the study sets out to establish a clear understanding of the overarm throw. The throw is described and analysed in terms of kinesiological, physiological, biomechanical, developmental and psychological factors. A number of experiments were conducted in an attempt to establish criteria for good performance of an overarm throw. Video tape was used to record many throws and repeated observations of the recorded throws have been made. As a result of the experiments and in combination with study of the literature it became clear that the key to the performance of a good throw was the establishment of the correct basic movement pattern. The final section outlines a method of teaching the overarm throw which seeks to develop the basic movement pattern.

CHAPTER I

THE OVER-ARM THROW

A DESCRIPTION AND DEFINITION OF TERMS

The term throw is used at times to describe a number of propelling actions such as rolling, tossing and slinging. The over-arm throw is the most commonly used method of projecting a small, light object over a relatively long distance with a reasonable degree of accuracy. A typical over-arm throw could be described as follows.

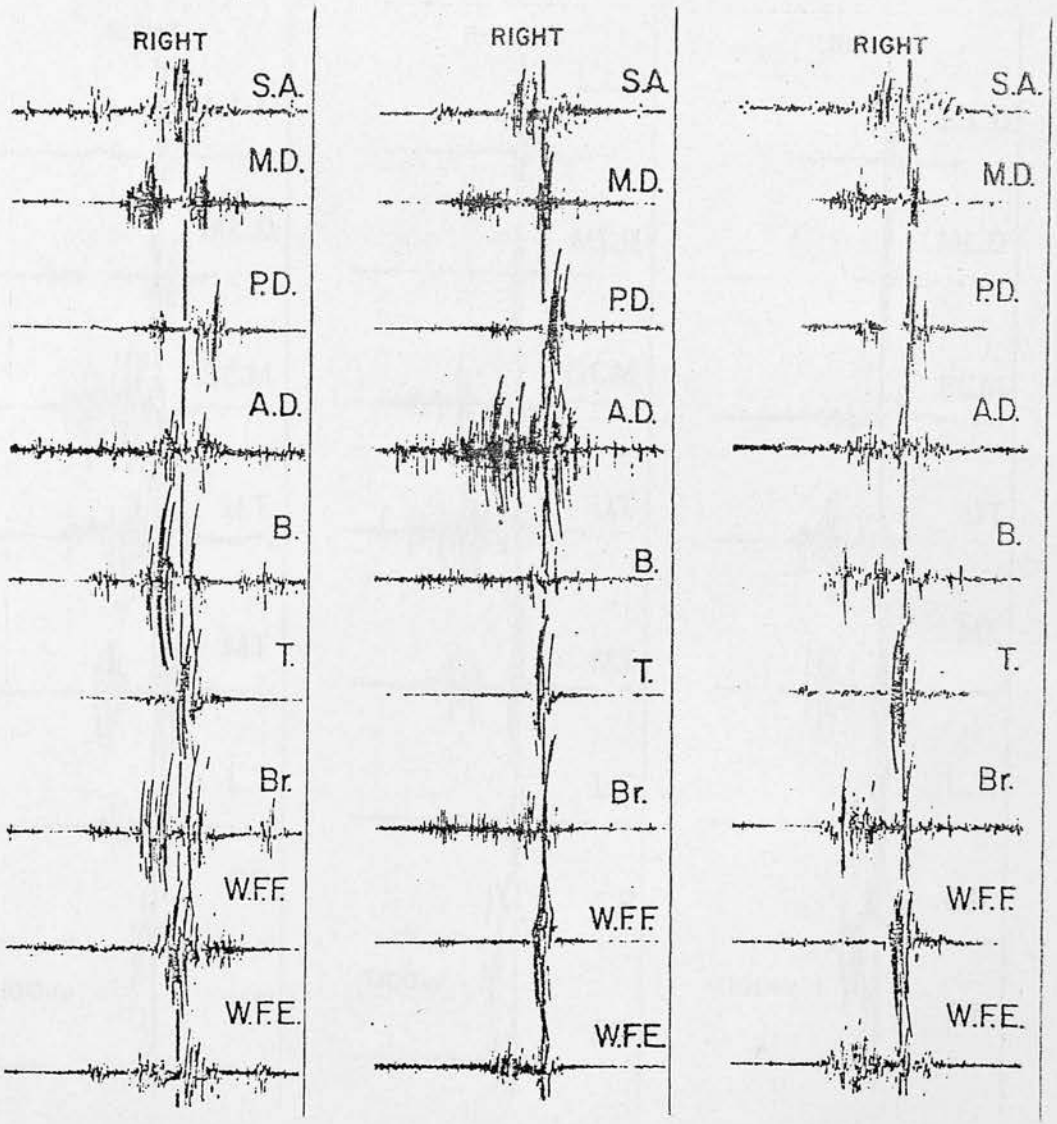
> The throwing arm is held above the shoulder, which has been turned away from the direction of the intended throw, with the elbow and forearm behind the plane of the head. The arm is swung forward with the elbow joint flexed and the elbow leading the wrist and hand. During this movement the shoulders rotate to the front, the arm begins to straighten and the missile is released. The elbow joint extension is completed during the follow-through phase of the action. From the initial flexed position the arm accelerates up to the point of release and then decelerates. Extra force may be generated through a forward run into the through, rotation of the hips and a transfer of weight from the rear foot to the front foot during the course of the throw.

The most extreme form of this action is probably the javelin throw, with distances of over 300 feet being achieved.

The over-arm throw as described above is the subject of this study and will be referred to simply as the throw. Although the discussion and experiments refer mainly to the throwing of a tennis ball a similar action is used to throw a javelin, play a badminton clear or serve at tennis. The validity of this statement may be seen by comparing the three electromyographical traces shown in figure I.[1] These traces show the electrical potential of the muscles during the three actions. The similarity of the traces is striking and indicates that the muscles acted in the same order but not necessarily with the same intensity.

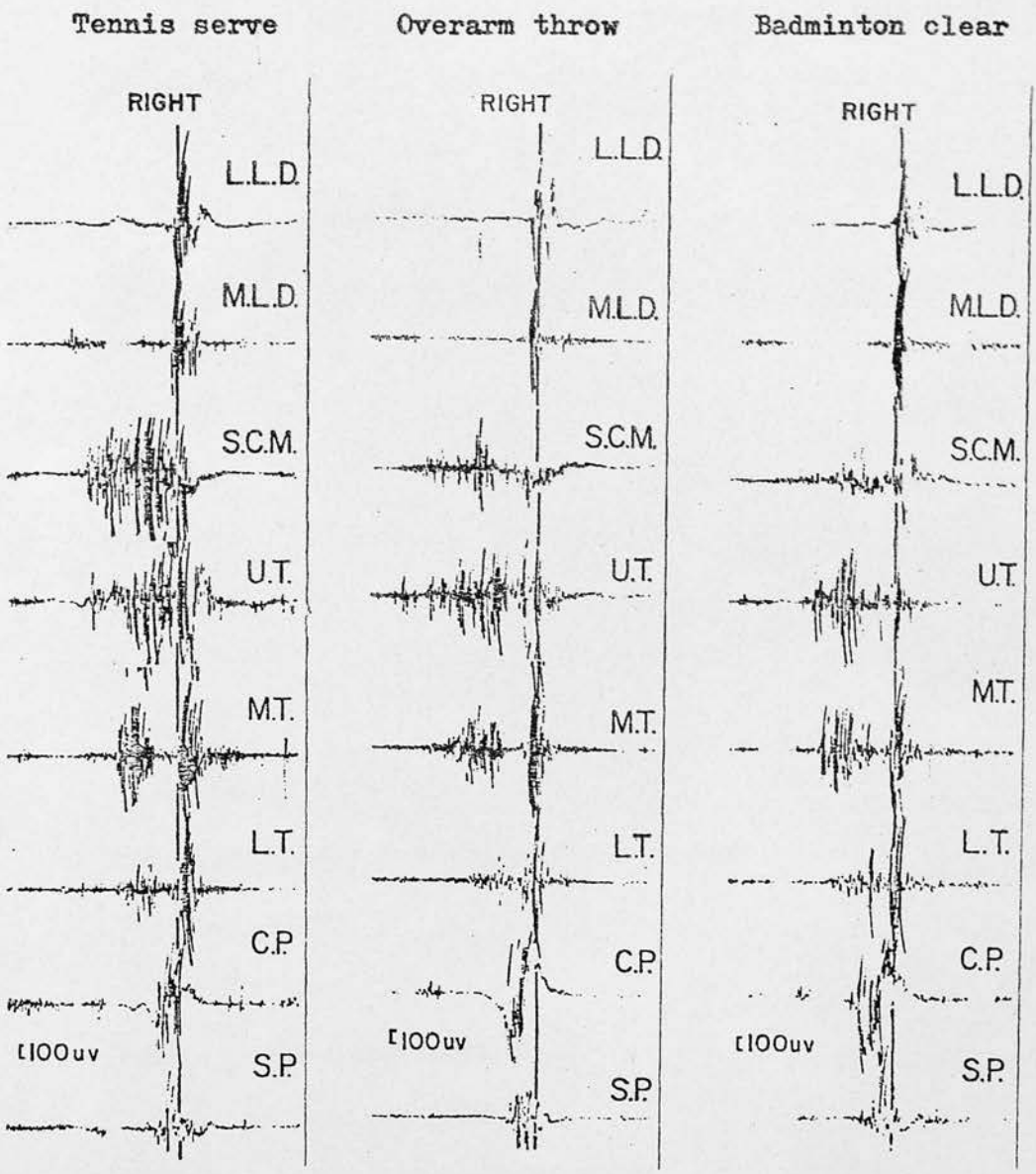
Figure I - Showing similarity of electromyographical traces made during a tennis serve, an overarm throw and a badminton clear.

Tennis sevre Overarm throw Badminton clear



Activity in muscles of the shoulder girdle and upper extremities.

S.A. - serratus anterior
M.D. - middle deltoid
P.D. - posterior deltoid
A.D. - anterior deltoid
B. - biceps
T. - triceps
Br. - brachioradialis
W.F.F. - wrist and finger flexors
W.F.E. - wrist and finger extensors



Activity in muscles of the shoulder girdle and upper extremities.

L.L.D.- lateral latissimus dorsi
M.L.D.- medial latissimus dorsi
S.C.M.- sternocleidomastoid
U.T. - upper trapezius
M.T. - middle trapezius
L.T. - lower trapezius
C.P. - clavicular pectoralis major
S.P. - sternal pectoralis major

The following list of sports and games will illustrate the frequency with which this action or slight variations of this action occur.

Athletics - javelin throwing
- cricketball throw
- roundersball throw

Cricket

Baseball

Softball

Rounders

Stoolball

Basketball

Netball

Handball

Captain Ball

Dodge ball - with many playground variants

Ducks and drakes

Waterpolo

Squash - service and smash

Tennis - service and smash

Badminton - over-arm clear and smash

Volleyball - spike

This list contains only formal games, some of which are played from school to international level. It does not include the countless make-up games of children's play which involve the throwing action.

It is not difficult to recognise a natural ball handler and thrower. There is a quality about the 'natural' , an ease even grace of movement and efficiency and sureness of performance. The results will speak for themselves. It is equally easy to spot the poor ball handler. There is

an awkwardness and an air of tension throughout the performance and a lack of consistency in the results. This quality of movement related to the action of throwing is referred to as the "form" of the throw. There would appear to be a close relationship between good form and success in throwing, measured in terms of distance and accuracy. This study seeks to establish this relationship and in order to do so attempts to evaluate form. Many tests have been devised to assess distance and accuracy in throwing but very few tests have tried to assess form. Probably the most exhaustive "form" evaluation was done by Gutteridge[2] in 1939 and this paper is described in detail in Appendix A. Gutteridge rates form by referring to the manifestations of the current throwing ability of the children involved. Her definition of form differs from the definition used in this study but her work illustrates the need to determine some objective factors upon which to make an assessment of form. In order to help find such factors two things have been attempted in order to get a deeper understanding of the throw and how it is performed. Firstly it is considered in terms of kinesiology, physiology and biomechanics. Skeletal differences and difference between the sexes are discussed and so too are developmental and psychological aspects of the throw. This discussion of the throw is to be found in the remainder of this chapter. Secondly video-tape recordings were made of a number of subjects throwing and the tapes were closely scrutinised. Some tests were conducted and on the basis of the findings, reported in chapter 2, and the discussion in this chapter an attempt was made to assess form.

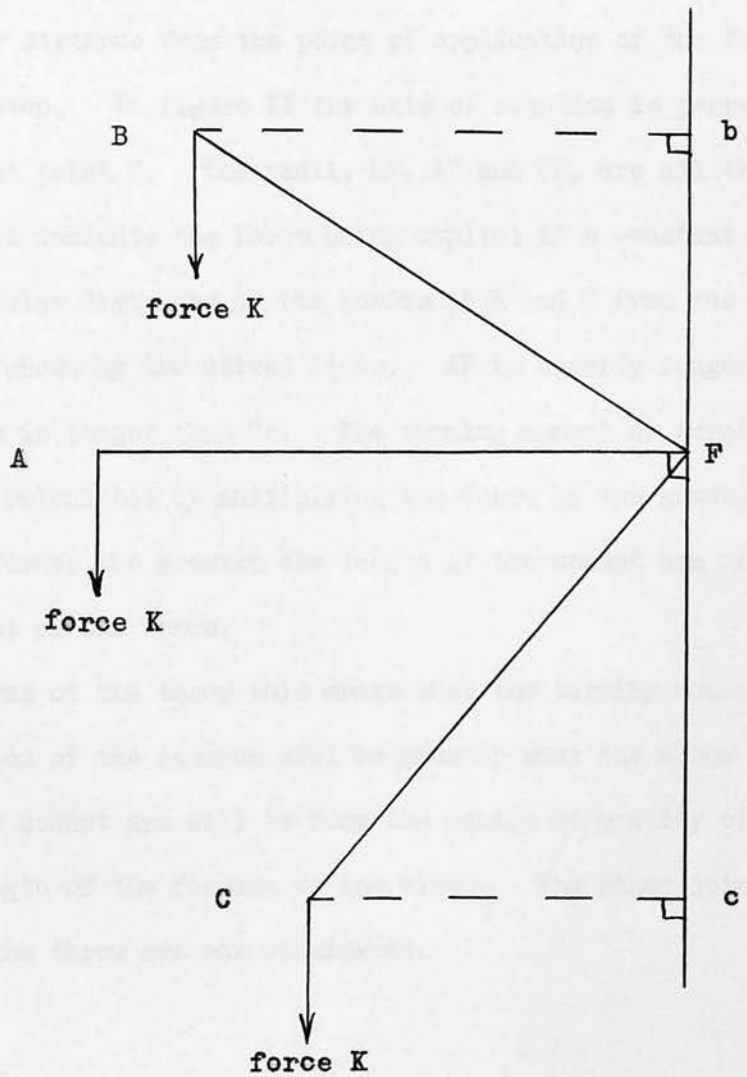
KINESIOLOGY

The distinguishing feature of the over-arm pattern of movement is the action at the shoulder joint in the preparatory phase. The humerus, the bone of the upper arm, has to be abducted to about 120° and rotated laterally. Abduction, the movement of a limb away from the vertical centre line of the body, to such a degree is only possible because of the ability of the scapula, shoulder blade, to rotate. This swing of the scapula with anti-clockwise rotation enables the humerus to abduct beyond 90° and extends the range of movement by a further 60°.

The range of rotation of the humerus is increased by movement of the scapula around the chest wall. As the scapula is abducted, moved towards the spine, the range of possible lateral rotation of the humerus is greatly increased. The muscles which produce the lateral rotation of the humerus are relatively weak whilst those producing the opposite motion, medial rotation, are relatively strong.

Lateral and medial rotation of the humerus can be understood by doing the following simple exercise. The upper arm is held horizontally to the side, in a position so that when the elbow is flexed at 90°, the forearm will be pointing horizontally, directly forward. Keep the upper arm to be side and move the forearm vertically to point upwards. This movement at the elbow has caused lateral rotation of the humerus. Return the forearm to the forward pointing position and the movement has caused medial rotation of the humerus. The movements of abduction followed by adduction and lateral rotation followed by medial rotation are important features of the over-arm throwing pattern. They also occur during the simple actions of combing ones hair or scratching the back of ones neck.

Figure II – Showing the moment arm of a simple lever system.



Each joint of the upper limb can do one or more actions and for each of these actions there is a maximum possible speed of movement. Analysis has shown the fastest joint action to be wrist flexion and the next fastest is the medial rotation of the humerus. However, the over-arm throw is concerned not just with rotation of the upper limb but also with rotation of the shoulder girdle, the trunk and the hips.

Rotation is caused by a force acting on a lever which turns about a fixed point or axis of rotation. The moment arm of the lever is the perpendicular distance from the point of application of the force to the axis of rotation. In figure II the axis of rotation is perpendicular to the page at point F. The radii, BF, AF and CF, are all the same length and the arrows indicate the force being applied in a constant direction. The perpendicular distances of the forces at B and C from the axis of rotation are shown by the dotted lines. AF is clearly longer than Bb which in turn is longer than Cc. The turning moment or turning effect of the force is calculated by multiplying the force by the moment arm. With three equal forces the greater the length of the moment arm the greater the turning moment of the force.

In terms of the throw this means that the turning moment producing medial rotation of the humerus will be greater when the elbow is flexed at 90^{o}. The moment arm will be from the centre of gravity of the ball along the length of the forearm to the elbow. The other joint actions involved in the throw are now considered.

Wrist

Wrist flexion is the fastest joint action of the upper limb. This fact combined with the wide range of movement possible allows the wrist to play an important part in imparting speed to the ball immediately prior to

release. The moment arm acting is short, about 5", and consists of the bones of the hand and fingers to the centre of gravity of the ball.

Hips

For a right handed thrower there is rotation of the pelvic girdle about the left hip joint. The pelvic rotation is facilitated by a transfer of the body weight. In the preparatory phase the weight is transferred to the right foot as the pelvis is rotated laterally to the right. This rotation may be 90° or more from the intended direction of flight of the ball. This rotation also assists the arm action by allowing the upper arm a greater range of abduction, which in turn permits a greater range of medial rotation of the humerus. During the force producing stage the left foot takes a step forward and the weight transfers to that foot. This allows medial or forward rotation of the hips about the left hip joint. The step alone is not important but combined with rotation of the hips and shoulder girdle it plays an important role. The moment arm acting in the medial hip rotation is made up of the pelvis, the spine the right side of the shoulder girdle and the right upper limb.

Spine

Rotation of the spine adds another lever to the system but the contribution is quite small. The moment arm in this case is the right half of the shoulder girdle and the right upper limb.

MECHANICS

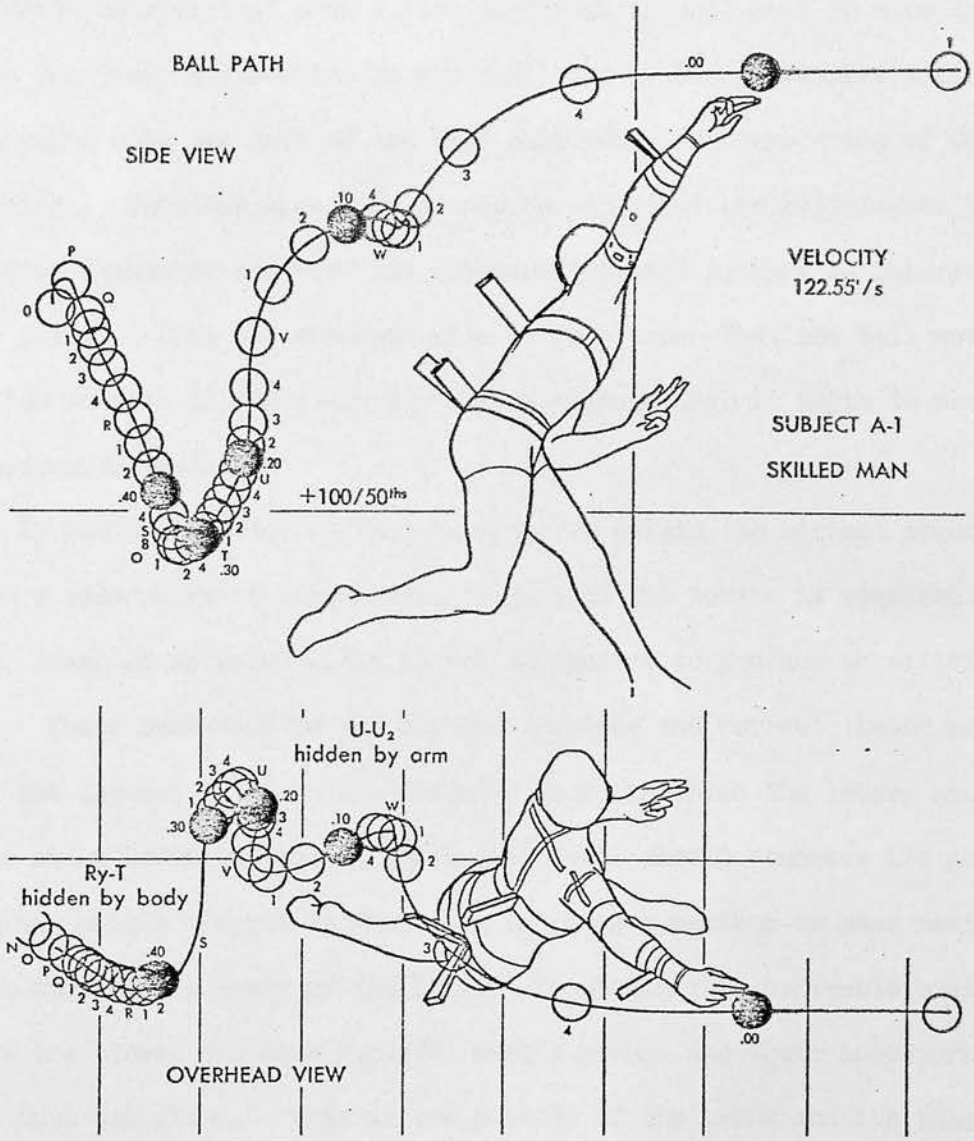
In very simple terms throwing is about transfer of momentum from the body to the ball. Momentum is calculated by multiplying the mass of a body by its velocity. It is possible by cine analysis to calculate the speed of each sequent of the body at release. The relative proportions of each sequent are known so it is possible to calculate the momentum of each sequent at release. Since the sequental momentums are additive it is easy to calculate the momentum of the whole body at release. The momentum will be nearly all transferred to the ball. Since the mass of the ball is known it is easy to calculate the speed of the ball at release and this is one of the two factors which determines how far the ball will travel.

The other distance determining factor is the angle to the horizontal at which the ball is released. When throwing a ball the height of the point of release above the ground is between six and eight feet. In that case the optimum angle of release will be nearer 40° than 45°, which would be the optimum angle if the ball were thrown from the same level at which it would land. However release angles of between 35°-45° will produce little performance difference for the same speed of release. This illustrates the fairly wide range of error possible without great detriment to the result.

The speed of the ball at release depends on the momentum of the whole body which in turn depends on the forces the body parts are able to generate during the throwing action. The various levers must be moved through as many degrees as possible so that they are able to exert force upon the ball for as long a time as possible. Other things being equal the greater total body force produces the greater speed since

FORCE = MASS x ACCELERATION.

Figure III - Tracings from film to show path of ball immediately prior to release.
(from Glasgow and Cooper: Kinesiology)

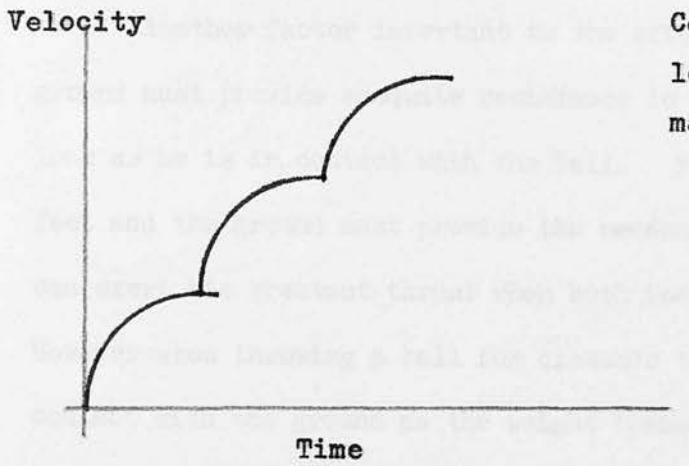


Each traced ball is taken froma single frame. The letter or number alongside each traced ball is a method of cross-reference from one view to the other. Thus V2 side view is the same frame as V2 overhead view. The time interval between consecutive lettered circles is constant. The black shaded circles represent the position of the ball at a fixed interval of 0.1seconds prior to and at release.

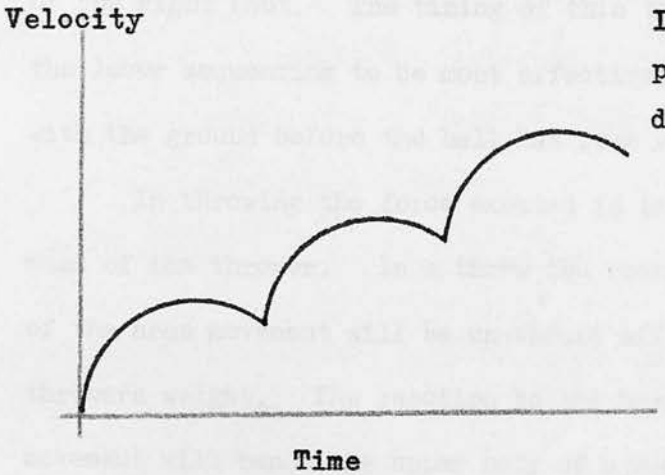
For efficient throwing the forces generated should be exerted against the ball in the direction of the intended throw. Figure III[3] illustrates however that even a good performer is only able to move the ball in the desired direction in the last half of the propulsive action. The diagrams show the path of the ball only after the completion of the back swing. From the side view it can be seen that the ball begins by travelling downwards and even its subsequent upward pathway is interrupted at one point. From the overhead view it is obvious that the ball moves from side to side and only shortly before release does it begin to move in the desired direction.

It has been explained that in order to obtain the highest speed of release a wide range of rotational movement of the levers is required. However range of movement alone is not sufficient to produce an efficient throw. There must also be the correct sequence and correct timing of the use of the levers. There is a definite order in which the levers should operate and a definite time at which each lever should commence its action. The levers should operate so that each can make a maximum or near maximum contribution to the speed of the ball. To obtain this desirable state of affairs the slower but more forceful muscle groups and their incorporated levers must act first. This is the muscles of the trunk and the thighs which move the spine and hip levers respectively. Later the relatively weaker but faster muscle groups and levers make their contribution after the ball has developed considerable speed. This is the shoulder, arm and wrist levers with the fastest acting joint the wrist coming into play last of all. It is important that each lever having attained its top speed should continue at that speed in support of the movements which follow.

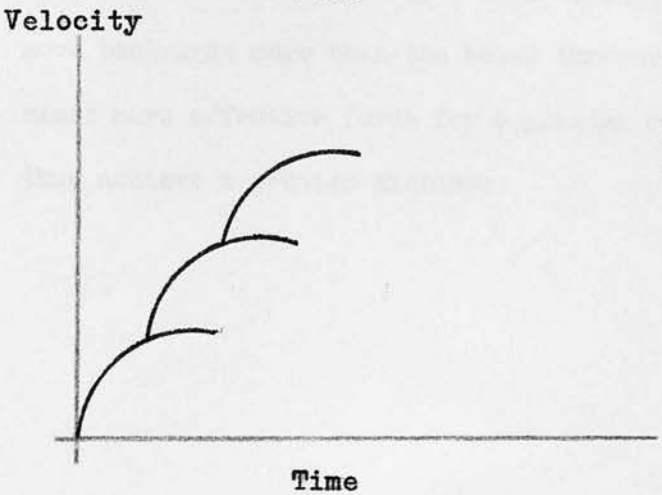
Figure IV - showing diagrammatically the timing of of a series of body levers during the performance of a skill. Each arc represents an individual lever.



Correct timing - previous lever has reached maximum velocity.



Incorrect timing - previous lever is slowing down.



Incorrect timing - Previous lever has not yet attained maximum velocity.

This principle is shown diagrammatically in fig. IV[4], with (a) being the 'ideal', showing each succeeding lever beginning to operate as the previous one has attained its top speed: (b) shows the subsequent levers coming into action too late and in (c) they are operating too early. This sequencing is vital and a thrower should not attempt to be so fast that he is unable to achieve the correct sequence.

Another factor important to the effective use of force is that the ground must provide adequate resistance to the throwers movements for as long as he is in contact with the ball. Friction between the throwers feet and the ground must provide the necessary counter-thrust. A thrower can exert his greatest thrust when both feet are in contact with the ground. However when throwing a ball for distance the right foot breaks effective contact with the ground as the weight transfer is completed by the thrust of the right foot. The timing of this thrust should fit correctly into the lever sequencing to be most effective. To lose completed contact with the ground before the ball has been released is quite incorrect.

In throwing the force exerted is to some extent dependent upon the mass of the thrower. In a throw the reaction to the vertical component of the arms movement will be up-thrust off the ground regardless of the throwers weight. The reaction to the horizontal component of the arms movement will cause the upper body of a comparatively light thrower to move backwards more than the heavy thrower. The heavier man can therefore exert more effective force for a greater range of movement and time and thus achieve a greater distance.

Individual skeletal differences and some implications

That individuals differ in lengths of skeletal parts is obvious and well known. Generally children are shorter than adults and the average man is taller than the average woman. Height is a combination of several bone lengths and it is quite possible to have two people with equal overall height but different leg lengths. This would obviously be countered by the person with the longer legs having a shorter back or neck. The lengths of the bones of the arm, humerus and radius and ulna, will also differ from individual to individual.

If two individuals can move their forearms during medial rotation of the humerus with the same angular velocity then the one with the longer forearm will have the greater linear velocity of the hand. This will in turn impart greater velocity to the ball. Not only may the bones be a different length but the muscle insertions, where the muscle joins on to the bone, may be different distances from the joints. This too will effect the linear velocity generated, the individual with the insertion closer to the joint generating a greater velocity for a similar shortening of the muscle length.

Some observed differences between male and female throwers

The differences between male and female throwing patterns can be best appreciated by looking at some research reported by Atwater[5]. Atwater considered the throw as consisting of four lever systems and has shown in the following table various parameters of the lever systems at the instant of release.

	Range of Mvmt. (degrees)	Angular Vel. (degrees/sec)	Moment Arm (feet)	Linear Vel. (feet/sec)
Man				
Hip rotation	20.6	824	2.12	30.5
Spinal rotation	9.6	384	2.75	18.4
Shoulder rotation	38.5	1540	0.27	7.3
Wrist flexion	60.0	8571	0.49	73.3
Woman				
Hip rotation	20.6	735	2.32	29.8
Spinal rotation	20.9	746	2.21	28.8
Shoulder rotation	29.0	1036	0.35	6.3
Wrist flexion	42.0	5250	0.37	33.9

The summed linear velocity for the man is 129.5 feet/sec and for the woman is 98.8 ft/sec. These figures would be approximately the velocity imparted to the ball at release. In both cases the wrist flexion makes the largest contribution to the linear velocity and the other three systems contribute in the same order. Both performers extended the elbow just before release and so shortened the length of moment arm of the shoulder system. (hand, forearm and upper arm). The measurements for this moment arm were shorter than those for the wrist lever which shows that the ball at release was less than 6" from a line extending through the humerus. The medial rotation of the humerus obviously makes its very important contribution before the time of release. Atwater reports that the elbow of the average woman is flexed 50-60 degrees at release while those of the skilled performers are all most completely extended.

Brüer & Houtz[21] in their book claim that the angle of release was approximately 105°. This agrees quite closely with a paper by Gollnick & Karpovitch[6] who found an elbow joint angle of 102° at moment of release during a baseball throw.

Atwater highlighted another difference between the groups when she measured the length of the stride into the throw. The mean stride lengths for each group was as follows:- skilled men 3.87 feet; skilled women 3.35 feet; average women 2.30 feet. A similar finding related to stride length is reported by Ekern. She found that the better throwers whose balls were projected fastest, had longer steps.

Velocities of balls projected by the overhand throw have been measured more frequently than any other movement pattern. Atwater, after doing her own experiments and studying the available data, suggested the following assessment standards:-

For skilled women a range of 70 - 80'/sec.
for average women 40 - 50'/sec.
and for skilled men 100 -120'/sec.

DEVELOPMENTAL ASPECT

It is not possible to discuss throwing fully without some reference to the developmental aspect, that is how the throwing pattern develops from infancy to a mature throwing form.

Godfrey & Kephart[7] have a list of fundamental or basic movement patterns which they suggest must be experienced and mastered in order that more complex and specific skills may be achieved. Their list is summarized as follows.

A. Body handling patterns

1. Locomotar patterns
   - crawling
   - walking
   - running
   - climbing
   - jumping
   - rolling
   - hopping
   - skipping

2. Balance patterns
   - standing
   - sitting
   - twisting
   - bending
   - stretching
   - swinging
   - rotating

B. Object handling patterns

1. Propulsive patterns
   - throwing
   - hitting
   - kicking
   - pushing
   - lifting

2. Absorptive patterns
   - catching
   - carrying

Wickstrom[8] in his book Fundamental Motor Patterns, considers the topic under the broad headings of running, jumping, throwing, catching, kicking and striking.

Gutteridge[22] in her study investigated the following activities:-

climbing, jumping, sliding, tricycling, hopping, galloping, skipping, throwing, catching and bouncing balls.

These three lists of what are considered to be basic or fundamental skills contain many similar items. One of the similarities is throwing. These three observers of child development and a number of others all considered throwing to be a basic and important skill without which overall motor development would be incomplete.

Motor development has its beginnings in the pre-natal period. From studies as early as 1884[9] on animal embryos definite sequences have been discernable in prenatal growth. The growth process in childhood follows a general direction, that is from head downwards to the end of the spine, from front to back and from a central line outwards to the ends of fingers and toes. Motor development is also along similar lines. There is a gradual development as bodily movement passes through stages of vague, exaggerated activity which slowly becomes more clear cut and purposeful. The child's body matures and control of it is perfected in response to the demands of and opportunities presented by the environment.

The above description is typical of the development of fundamental skill, and throwing just as surely follows the same lines. Gessels[10] describes in detail the development of the throwing action. His detailed observations are presented in Appendix B and summarized below.

Up to about three years of age the arm and shoulder joint alone are used in the throwing pattern. There may be a slight sway of the trunk, backwards and then forwards, the feet do not change position and there is no rotation of the body. The next stage, 3 to 4 years, is characterized by the introduction of rotatory movements. The shoulders

are rotated adding extra leverage to the throw but the feet may still be together preventing the hips from rotating. Also the finger release mechanisms are working more efficiently and permit greater control of direction. During the next year 4-5, a forward step is added to the pattern and this adds momentum to the throw. However using the same foot as the throwing arm for the forward stride limits the range of backward preparatory movements. This also makes the timing of the throw appear awkward. The final stage in the initial development of the basic pattern is the introduction of the opposition of the front foot and the throwing arm. This begins to occur at age 5 for boys and age 6 for girls. This permits full rotation of the hips, shoulders, arm and wrist so that the lever system is complete. By this final stage of development of the throwing pattern all the main factors are present as in the mature throw of the adult. The remaining are of improvement is the refinement of coordination and timing of the whole movement sequence. This will be achieved with a great deal of practice in a variety of throwing situations.

Jones[11] also studied development of motor skills in 2, 3 and 4 year olds as they played with wheeled toys. After long observation it was found that while basic performance seemed to depend upon maturation the development of skill was more attributable to practice. Hicks[12] on the other hand found that when 3-4 year olds attempt to throw for accuracy a typical method was difficult to identify and individual variations were noted. (This fits in with the findings of the present study although its subjects were adults and not youngsters. This is reported in the next chapter). The performance gains were attributed to maturation rather than practice since when instruction was introduced it could account for

little improvement. There are however obvious problems in trying to separate practice effects from maturation. Both researchers are indirectly suggesting that until the basic movement pattern has emerged through maturation then improvement in skill level through practice is unlikely.

Different researchers have suggested that this final stage of development of the basic movement pattern is reached more quickly by boys than girls. Gessels says that the shifting of the weight to the opposite foot from the throwing arm is evidenced by boys at five years and by some girls at six years. Gessels observations also lead him to suggest that throwing by 5 and 6 year old boys had many characteristics of mature throwing. Wild (1938)[13] found a similar state of affairs. Dohrmann (1964)[14] found that 8 year old boys were better than girls at throwing. Gessels was more explicit on that topic saying,

> "Boys throw much further and more accurately than girls, and are obviously more masculine in their style of delivery. Here is a constitutional sex difference in behaviour which can scarcely be ascribed to cultural factors. The sex difference becomes evident well before the age of five."

Goodenough & Brian[15] and Hicks[23] reported that boys are superior to girls in ball-throwing tasks at the age of 2-3 years. Hicks conjectured that the adults may have manipulated the environment in favour of boys. Goodenough and Brian found that behaviour that contributed to inaccuracy included: the lack of attention, elation due to success (this produced over throwing on the following trial), and in-correct focusing of attention (looking at the arm instead of the target). This latter cause could be due to an as yet undeveloped sense of kinesthetic awareness. This is the sense of position and movement and enables a person to know what position an unseen part of their body is in or at what speed and in what direction

a segment may be moving.

Movement behaviour in childhood, from 5-10 years of age, becomes more stable as growth decelerates. For example, a 10 year old is less likely suddenly to change his method of throwing than a four year old who may well be still at the stage of experimenting to find success. With more control than previously the child enjoys movement for its own sake. There is a transition from developmental patterns of movement to acquisition of skill in specific games. It is during this period that Cratty suggests that major emphasis upon basic activities, throwing, running and jumping, should occur. In this way a smooth progression will be made into movement behaviours which will be required and socially acceptable during adolescence. Using a battery of tests designed to evaluate motor ability Seils[16] found that relationships did exist between skeletal maturity and gross motor performance items, including throwing and catching by both boys and girls, and jumping for girls. Amongst other things Seils findings indicated the growing importance of body build during this period of life. The work of these two researchers indicate that the early physical developer is at an advantage when it comes to mastering the basic physical skills.

SOME PSYCHOLOGICAL CONSIDERATIONS

It is necessary to consider why a child might be unable to throw and what implications this might have. One reason may be that the child is motor impaired in some way. Motor impairment may have one of two basic causes, either brain damage or deprivation. It has been suggested by Morris & Whiting[17] that everyone is brain damaged and that it is just a question of degree. For the vast majority of the human race any such damage is quite unnoticeable, but for a small minority with considerable brain damage the results are very serious.

In todays social climate of enlightenment, persons who are severely motor impaired, spatistics etc., are accepted for what they are, their limitations are realized and their achievements are given due credit. However the child who is only slightly impaired is often not understood and because of this is at a disadvantage. There may be no obvious explanation for his clumsiness and he may either be teased or totally ignored. In either case he is to some extent a social misfit, particularly when it comes to playing games. He is either not allowed to join in or in a team game may be told to play in a position where there is little or no involvement at the level at which the game is being played. Either situation offers little opportunity for practice of the skill at which the child is not proficient. Without practice the child is unlikely to improve sufficiently to gain the social acceptance which he would dearly like.

In the peer group of the primary school child the individuals are judged upon the basis of what they can do and not on their powers of reasoning. A child who cannot or is unwilling to engage in rough physical games is not generally accorded as high a place in the group heirarchy as the one who participates vigorously in every game going. Jones[18] went

even further than that and suggested that successful participation in athletics (this american term embraces all sports), by males from the ages of 6-20 will tend to enhance their status and potential for leadership. She also implied that status is conferred depending upon the degree of excellence exhibited.

Such heirarchical positionings often carry over into non-physical situations particularly in the primary school age range. Research[19] has shown that the children who are most liked are either average or above average in physical ability. Another finding is that slight positive correlations are usually obtained when comparing the social attributes of children to their physical skills.

The above paragraphs illustrate clearly the importance of simple physical skills to the youngster in primary school. The child who cannot throw in the context of that particular situation is motor impaired and so may not be highly regarded by his peers. In order to avoid the taunts of his fellows he may not attempt to join in thus hiding his inability. This lack of practice and play will not enable the child to improve this basic skill and so his motor development will be incomplete.

As previously stated it is difficult to separate the effects of practice from maturation. The child may not be able to throw because he has not matured, either physically or perceptually. His musculature may not be strong enough or his hand/eye coordination may not have developed sufficiently. In either case lack of practice with his fellows may hinder his maturation and further may undermine his confidence. In such an example the motor impairment is enhanced by a deprivation situation. If however the motor impairment is caused by physical brain damage or neural

dysfunction it is unlikely that inability to throw is the only problem. There will almost certainly be other possibly more serious physical problems and probably some cognitive problems as well. Help for such a child may well be needed at a clinic specializing in remedial education. The less seriously impaired child or the late developer is the child who may have problems with throwing whilst in the primary school and it is such children that this study is concerned to help.

CHAPTER II

EXPERIMENTATION - THE TESTS

The Methodology

This study was begun by questioning the following statements.

a) Most women can't throw properly.

b) Boys are better at throwing than girls.

c) A number of men never learn to throw properly.

The first sweeping statement is often challenged by the women present when the statement is made, and it is true that there is no hard evidence to support it. However observation of a simple game of beach cricket will show that "some" women can't throw properly and neither can "some" men. Teaching experience in primary or secondary schools illustrates that some children do have difficulty with throwing. It is possible that some of them will master the skill at a later stage of development but others will not and will therefore be unable to throw properly throughout their lives.

The following questions were posed in an attempt to be able to clarify the above statements.

i) What percentage of adults cannot throw well?

ii) What is a good throw and how is it performed?

iii) What is it that those who cannot throw well do not do correctly?

iv) Is it possible to teach throwing to those who have difficulty and when is the best time to give appropriate instruction?

As has been stated earlier it is not difficult for a p.e. trained person to spot the non-thrower. What is more difficult to spot is exactly what is wrong. Repeated observation of the thrower may help but a

permanent record of the thrower will allow more detailed analysis to be carried out. It was decided that the answers to some of the above questions might be found by doing an analysis using video tape equipment. A description of the equipment used may be found in the Appendix E. Using this equipment it is possible to replay the action as many times as is required and also to stop the movement at any point during the action. Tracings made from the video tapes appear in Appendix C. In this way it should be possible to answer both parts of question (ii) and by studying poor throwers to find the faults and so answer question (iii). It is only possible to answer question (i) by testing a large number of subjects and rating their performance in some way. The fourth question is much more difficult to answer than the others but it is the most important of the questions. The final section of this study attempts to deal with this. However before an attempt to answer question (iv) can be made it is necessary to have a deep and clear understanding of all the factors involved in a throw and throwing ability. Some of the theoretical factors have been dealt with in the previous chapter and some practical insight can be obtained by attempting to answer the first three questions.

Initially the important thing was to establish what exactly constituted a 'good' throw. Consequently the first video taping was done using three good throwers as assessed subjectively by members of the staff of the Physical Education Department of Edinburgh University.

The subjects were instructed to stand at a fixed point with one foot in front of the other. The stance was in front of a set of gymnasium wall bars which provided a vertical and horizontal reference grid for use during the analysis. A three foot diameter target was suspended

with its mid point eight feet from the ground at a distance of fifteen feet from the subjects. The subjects were instructed to throw the tennis balls at the target as hard as they possibly could. During these tests no note was taken of whether the subjects hit the target or not.

The subjects were videoed using firstly their dominant or preferred hands and then their non-dominant hands. This was done in order to have a record of each subject doing a series of good throws (dominant hand) and a series of poor throws (non-dominant hand). By comparing the 'good' and the 'poor' throws it was possible to find the major differences between them. In this way it was possible to highlight the key points of a 'good' throw and to identify some of the faults which occurred. The vital points in a 'good' throw are summarized below.

1. A right handed thrower will have the left leg forward and vice versa.
2. There will be considerable rotation of both hips and shoulders.
3. There will be a noticeable weight transfer from the rear to the front foot.
4. The preparatory phase will place the hand holding the ball above and behind the head.
5. The elbow will lead the whip-like arm action of the propulsive phase.
6. The whole action should be fluent, with no jerks or pauses, and should look natural and easy.

The most common faults which occur are as follows.

a) Little or no rotation of the hips and shoulders thus limiting

the potential speed at release of the ball.

b) A pushing or lobbing arm action possibly caused by having the hand in front of and below head height at the commencement of the propulsive phase. Lack of speed of shoulder movement may also be a cause of this fault.

c) The whole action may be done too quickly for the thrower to control the correct timing of the release of the ball.

d) The whole action will appear awkward lacking fluency and coordination.

After the initial group of three subjects had been videoed and the tapes studied a second group was tested under similar conditions. This group consisted of thirteen subjects, ten of whom were students and the other three being children, two girls aged five and eight and a boy aged nine.

From a close scrutiny of the tapes of both groups a number of things became apparent.

i) A definite pattern of movement was used by the good throwers of both groups.

ii) The pattern was basic, containing in sequence the key points already outlined, but the actions were not identical, there being individual variations.

iii) Poor throwers varied in some way from this basic pattern.

iv) The students were consistent with their throwing actions, even the poorer throwers.

v) The children were inconsistent in their throwing actions, even the nine year old boy whose action was quite mature. The children

had to be reminded frequently to throw as hard as they could. (see Appendix C.)

vi) Even using video equipment assessment of a throw was not easy. To categorise a throw as simply good or bad was inadequate since there was a range of performances varying in quality.

One of the aims of the tests so far had been to establish some criteria for a good throw, but only the action of the throw had been studied and the result of the throw had been ignored. It was possible by watching the subject and by studying the tape to pick out the good throwing actions and the poor throwing actions but it was not possible to tie this in with the result of the throw.

A throw may have a result in terms of distance or accuracy or both and in order to assess these criteria two simple tests were devised. The results of these tests coupled with video tape assessment of the form of the throwing action enabled a more complete assessment to be made of the throw.

THROWING TEST A. (ACCURACY)

The equipment used was a large archery target supported on a stand so that the centre of the target was four feet six inches (4' 6") above the ground. The subjects stood behind a throwing line twenty five feet (25') from the target. The balls used were standard tennis balls. The scoring used was 5, 4, 3, 2, 1 working outwards from the gold to the outside ring of the target. The final score for the subject was the aggregate score of fifteen (15) test throws. The subjects were instructed to stand up to the throwing line, no run or stride into the throw being

permitted, and that they should aim to score as many points as possible. Five (5) practice throws were followed by fifteen test throws. A video tape recording was made of each subjects first three scoring throws.

THROWING TEST D (DISTANCE)

It is not always possible or convenient to take subjects outside to a playground or playing fields to do a distance throwing test so this test was carried out in the P.E. Department sportshall which measures 80' x 35'. In such an area it was not possible to use a tennis ball since most of the subjects who were university students would throw further than 80'. Instead tennis ball sized airflow balls were used. A throwing line was used 5 yards from one end of the hall and the subjects were permitted to run up to the line. Each subject had three throws and the distance of the longest throw, measured to the nearest foot, was the subjects score. A video tape recording was made of each subject's three throws.

Airflow balls are seldom used in actual games play being most widely used in teaching situations. Thus it was possible that some of the subjects had not used such a ball for a long time and some might never have used one at all. It was important therefore to be able to answer the question as to whether the person who threw the airflow ball the farthest could also throw the tennis ball farthest and was the poorest thrower with one type of ball also the poorest with the other type. In order to be able to answer this the subjects undertook a third test which was throwing a tennis ball for distance. This was done at the university playing fields. The run up or approach was limited to five yards as in the airflow

ball test and the scoring was achieved in the same way. Video tape recordings were also made.

Four separate groups of subjects were used on combinations of the tests detailed above.

Group I

Group one were twenty (20) physiotherapy trainees who attended the P.E. Dept., as part of their course. They were all female and their average age was 18 years. Of the group two were left handed. Initially they did Test D (airflow) and Test A. The distance test was done in the sportshall and the accuracy test was done in the adjacent gymnasium. Both test together took just 45 minutes to administer. To fit in with the students teaching programme eleven of the group did the test one week and the other nine did them a week later. The results of the two half groups were combined to give one set of data. (Group I, Data sheet I). All data is presented in Appendix D. Two weeks later the whole group did Test D (tennis). This test was done at Peffermill playing fields and the conditions were cold and dull but there was little wind. The results of Test D (airflow) and Test D (tennis) were combined to make one set of comparative data. (Group I, Data sheet II).

Two and a half months later this whole group was retested on Test D (airflow) and Test D (tennis) to provide a third set of data. (Group I, Data sheet III). The retests were done as a check on the reliability of the tests themselves and the constancy of the statistical results.

Group II

This group consisted of twenty members of Edinburgh University Ladies

Hockey Club and all of them were either 1st or 2nd team players. Only one of the group threw with her left hand. The average age of the group was 19.5 yrs. This group was tested on Test D (airflow) and Test D (tennis). Video tape equipment was not available. Both tests were conducted outdoors at the playing fields. This invalidates any comparisons of the results of this group on Test D (airflow) with the results achieved by group I on the same test. Comparison between the two tests done by this group are valid as are inter-group comparisons on Test D (tennis). The results of these two tests form another set of data (Group II Data Sheet I).

Group III

This group with an average age of 20.4 yrs., consisting of five males and one female, were a squash beginners class. They were tested on Test A and Test D (airflow). The video tape equipment broke down during the first test so form was assessed by the tester. (Group III Data sheetI).

Group IV

This group consisted of 24 male prison officers who were attending an official P.T. Instructors Training Course which was run in the E.U. Department of P.E. on behalf of the Scottish Home and Health Department. Of this group three were left handed. Their average age was 29.9 years. This group did Test D (airflow) and Test D (tennis). (Group IV Data sheet I).

The statistical methods used on the data were Spearmans Rho Rank Order correlation and a t test. The results are summarized in Tables I & II.

Table I Rank order correlations between Accuracy and Distance (airflow)

Group I	n = 20	p = 0.194	t = 0.837	N.S.
Group III	n = 6	p = 0.185	t = 0.378	N.S.

Table II Rank order correlations between Test D (tennis) and Test D (airflow)

Group I	n = 17	p = 0.723	t = 4.06	.001
Group I (retest)	n = 19	p = 0.637	t = 3.4	.01
Group II	n = 20	p = 0.855	t = 7.00	.001
Group IV	n = 20	p = 0.792	t = 5.5	.001

Table III Rank order correlations between Form and Throwing tests

Accuracy

Group I	n = 20	p = -0.112	t = -0.47	N.S.
Group III	n = 5	p = -0.2	t = -0.35	N.S.

Distance

Group I	n = 20	p = 0.687	t = 4.01	.001
Group III	n = 5	p = 0.95	t = 5.26	.02
Group IV	n = 22	p = 0.53	t = 2.8	.02

Table I shows the rank order correlations between the results of Test A and Test D (airflow). For both group I ($p = 0.194$, $t = 0.837$) and Group II ($p = 0.185$, $t = 0.378$) there appears to be no significant correlation between accuracy and distance throwing as defined by the two tests used.

Table II shows the rank order correlations between the two distance throwing tests, Test D (airflow) and Test D (tennis). In each case there appears to be a strong relationship between the two tests used, 3 groups at the 0.001 level of significance and one group, the physiotherapists retest, at 0.01 level of significance. This high positive correlation between the two tests may be of considerable use. It suggests that when testing throwing for distance it would be quite valid to use an airflow ball thus requiring much less space in which to conduct the test and that it can be done indoors if necessary. It would under normal circumstances be preferable to use a tennis ball because it is a much more usual type of ball for children to play with. If however conditions outside were inclement or no suitable space was available then an airflow ball could be used as a valid substitute. This applies only to deciding who the good throwers and who are the poor throwers. It does not indicate how far a person can throw a tennis ball.

THE USE OF VIDEO TAPES IN ASSESSING FORM

The results so far presented and discussed have dealt with the throw in terms of accuracy and distance. However it was one of the intentions of this study to be able to relate these two criteria to form and so obtain a complete picture of a throw. To do this video tape

recordings were made of many of the throws. As previously stated study of the initial sets of video tapes had made it possible to identify the key points of a throw and from this list a method of assessing form on a ten point scale was devised. The method of assessment adopted was as follows.

Four key areas were selected for consideration and they were: i) the stance ii) hip rotation iii) shoulder rotation and arm position iv) arm action. The scoring was done in the following manner.

i) If the stance was made with the correct foot forward and there was a definite weight transfer then one point was scored. If the incorrect foot was forward or little or no weight transfer took place then no points were scored.

ii) Marks out on three were given for the amount of hip rotation which occurred during the preparatory and propulsive phases. Full rotation of 90^{o} scored three points, rotation less than 60^{o} but more than 30^{o} scored two points and rotation less than 30^{o} scored one point.

iii) The shoulder rotation was scored in a similar manner to the hip rotation but in addition the position of the arm was considered. For a full three marks the shoulders had to be rotated between 60^{o} - 90^{o} and the throwing arm had to be held above shoulder level, with the elbow behind the plane of the head and the hand and ball behind the plane of the elbow. If the elbow was low or in front of the head or the wrist in front of the elbow marks were lost accordingly.

iv) The arm action during the propulsive and release phases was marked out of three. If the correct whip like action occurred and the arm was high on release then three marks were given. If the action was slow and merely produced a lob then two points were given. If the arm action was

a push with the arm and elbow low then only one point was given.

Using the above criteria a mark out of ten was given for each recorded throw.

Groups I & III were assessed in this way on Test A and Test D (airflow) and Group IV was assessed on Test D (tennis). The results of this assessment have been ranked for each group and then correlated with the rank order of the results of the throw. The correlations are shown in Table III. From these results there appears to be a very weak negative relationship between form and performance on the particular accuracy test used. The relationship between form and these particular distance throw tests appears to be very strong for group III ($p = 0.95$ 0.02), and substantial for group I ($p = 0.687$ 0.001) and group IV ($p = 0.53$ 0.02). The relationship between form and distance emphasises the need for correct technique in throwing for distance. However correct technique appears unnecessary to achieve a high score on the accuracy test. If the target had been further away from the subject it is possible that more emphasis on technique would have been called for.

The data for all the tests is presented in the appendices. Comparison of Group IV data sheet II (prison officers, form v distance) and Group I data sheet IV (physiotherapists, form v distance) reveals that the females were poorer throwers than the men in terms of form. Except for possibly one individual the men all exhibited the correct throwing pattern their non maximum scores being a matter of degree rather than omission or error. For instance all of the men had correct arm actions during the propulsive and release phases. The lowest scores in the female group were largely attributable to incorrect movements during the release phase.

CRITICISM OF THE TESTS

1. Video tape is not the ideal analysis medium, the main fault being that because there are no frames giving discreet pictures it is not possible to be sure of stopping at exactly the same point on a subsequent viewing. This makes exact measurement during the assessment of form rather difficult and therefore this is a source of error. Cine film is a much more accurate medium to use for analysis but video tape does have two advantages for work not demanding great accuracy. Firstly the replay facility is almost immediate whereas cine film might take weeks to be developed, and secondly video is less expensive since the tape may be reused a number of times.

2. A possible source of error in Test D (airflow) was the fact that the person marking where the ball landed was not the same person in each test nor in fact the same person throughout an entire test. Since the ball left no mark on landing the marker had to fixate on the landing spot, move to it and then mark it with chalk. This combined with the fact that the throws were measured to the nearest foot gave a possible total error of two feet.

3. The source of error with Test A was in seeing where the ball actually hit the target. With a distance of only twenty five feet if the ball was thrown hard the time in contact with or close to the target was extremely short. If the ball overlapped between two target rings then the decision was even more difficult. Such errors if they occurred will have been minimised since the same person did the scoring on all occasions.

4. Test D (tennis) was conducted outside so the vagaries of the wind on the different occasions make comparisons a little dubious. However the tests were always conducted in a direction to give a following wind.

5. Insufficient numbers have been used to be able to state how many of the adult population have difficulty with throwing. Although the testees were adults they were hardly representative of the general population.

CONCLUSIONS

The possible conclusions to come from the tests are as follows.

1. There appears to be no relationship between form and success on Test A.

2. The results show a marked relationship between form and success in throwing for distance in both Test D (airflow) and Test D (tennis).

3. Since the distance throwing tests were very simple and had few constraints it is possible to extend the relationship of form to distance throwing in general.

4. The results show no relationship between success in Test A and success in Test D.

5. The relationship between Test D (airflow) and Test D (tennis) appears to be consistant and marked.

6. There are notable differences between the throwing performances using a tennis ball of the hockey players (mean 96.45 ft) and the physiotherapy trainees (mean 72.35 ft). A possible explanation of this difference in performance could be the hockey players' greater involvement in games and sports leading to greater familiarity with and practice of ball handling skills. However it might be suggested that it is their ability to throw which has enabled them to become involved in sporting activities.

The conclusions above are not in themselves of great moment. However in combination with the theory covered in the previous chapter the tests have been instrumental in indicating the direction for further study to follow. It would appear that the vital factor to consider is not the result of the throw, be it for distance or even accuracy, since most games situations demand a combination of accuracy with distance, but the basic movement pattern and its development. It is on this premise that the final chapter is based.

CHAPTER III

TEACHING THE OVERARM THROW

"All teachers observing the play activities of children should be sensitive to the children who cannot or do not act, and should attempt to ascertain the reason for their reluctance. The teacher should attempt to provide situations in which inumerable activities are available so that all children can participate. Specific instruction in skills should be given the inept performers. Some children seem able to copy the throwing pattern and other appropriate skills from their more successful peers, while others cannot. The teacher should provide appropriate instruction periods for the latter individuals".

Cratty B.J.[20]

The establishment of the correct movement pattern and its development are essential for success in throwing. For the majority of children this is a natural part of motor development but others need specific help and plenty of opportunity for practising this basic skill. The movement pattern can be broken down into easily identifiable parts which can be effectively taught separately.

The best age at which to give instruction to those who require it is indicated by reference to Gesells and Gutheridge. Gesells found that rudimentary throwing begins towards the end of the first year of life. It then progresses until between 6 and 8 most children adopt the basic overarm throwing pattern. Gutheridge[24] in her survey shows that by the age of seven nearly three quarters (74%) of her sample were rated 8 or better. Reference to her rating scale shows that grade 8 indicates that the basic habit has been consistently achieved and the movements are coordinated. If the primary age range from 6 - 11 is when the great majority of children are succeeding, it is during this period that the rest may be having problems. It is important therefore that the children who are having difficulty are identified and that the appropriate help is given.

Occasionally in England a physical education specialist may be appointed to the staff of a primary school. Sometimes in both England and Scotland a teacher from the local secondary school will visit the feeder primary schools to teach some physical education. However, it usually falls to the lot of the primary class teacher to take the physical education lessons. Many of them do a competent job but unfortunately there is often a lack of understanding of the aims of physical education in the primary school.

All students training to be primary teachers are required to do a basic course in physical education which will enable them to teach the subject in school. The length of time allocated to such a course indicates that physical education is very much a poor relation among the primary school subjects. Often the emphasis of the courses tends to be on the content and not on the reasoning behind it. This must put a question mark against the colleges' thinking about primary school physical education. Even the specialist physical education colleges give scant regard to what should be considered one of the most vital stages of their work.

Perhaps the primary basic courses have merely followed the trend of many specialist colleges where overmuch emphasis has been placed on modern educational gymnastics. This form of gymnastics requires the teacher to set the children a task and they are permitted to solve the task in their own way, thus each child works at his or her own level. Taught properly this is extremely demanding of the teacher and can also demand much of the children. There is however little direct teaching required which makes it well suited to teachers who have limited technical knowledge or practical ability. A primary course based on modern educational gymnastics may well give a teacher confidence in giving commands and using the right language to describe the movements but the teacher may find difficulty in correcting faults and extending the children towards the limits of their ability. Good teaching of any subject requires that the teacher has a sound background knowledge and experience of the subject and is not merely one step ahead of the pupils. However it appears that this principle is not considered necessary for

the teaching of physical education.

Even if colleges have devoted reasonable time to the basic courses and have included relevant material a teacher lacking practical ability and understanding of the principles involved may lack confidence in front of a class of thirty five youngsters. A lack of confidence may lead to one of two things. Firstly a teacher may attempt to hide his or her lack of ability under a flurry of activities with no teaching as such occurring. Secondly the physical education lessons may be avoided altogether on some occasions. It is easy and on some occasions feasible to make excuses to carry on with the lesson in hand and so avoid gym.

The physical education lesson may often be regarded as simply a time for the children to play games, enjoy themselves and to let off steam so that they are slightly more docile in the next lesson. These aims are in themselves worthwhile but the underlying aim of proficiency in the basic skills of running, jumping, throwing, catching, climbing, kicking and striking is forgotten. These two different aims, fun and proficiency, may be fulfilled in the same lesson. It is quite possible for a teacher to make various teaching points and to use them in activities or exercises which are enjoyable. This is the basis of good teaching in physical education.

One problem which non-specialist primary teachers may have is that of observation, in the practical situation. All good teachers need to be acute observers of behaviour but there are differences between observing in the classroom and in the gymnasium situation. The classroom is a relatively static situation whereas the physical education

lesson will be dynamic most of the time. The fact that the children are all on the move requires of the teacher a certain discipline to be able to observe effectively. It is necessary to select a child and to watch that child constantly for a short period of time depending on the activity being practised. All other movements or distractions should be relegated to the background. In the gym the results of behaviour are frequently not permanent, the required action having been performed all that remains is an impression on the teachers memory. However in the classroom behaviour usually leaves a permanent record either in pencil, ink or paint. With this concrete evidence recognition of faults and correction is relatively easy. It is not being suggested that the class teacher in a primary physical education lesson cannot do a competent and in some cases good job but that for the non-specialist with perhaps limited physical activity background it is much more difficult.

The following sections of this chapter indicate the important elements of the pattern of movement involved in the throw, some common errors and suggests some appropriate activities for teaching the throw.

POINTS TO OBSERVE WHEN LOOKING FOR A CORRECT PATTERN OF MOVEMENT

1. Opposition of arm and leg - left leg forward for a right-handed thrower and vice versa. The wrong leg forward means little or no rotation is possible.

2. Rotation of the hips - this is related to (1), the longer the stride the more rotation is possible. Rotation backwards during the preparatory phase and forwards during the propulsive phase is important.

3. Weight shift - does the weight come forward from the right foot to the left foot as the throw progresses through the propulsive phase?

This helps to impart greater momentum to the ball at release.

4. Opening of the shoulders - as proficiency increases this rotation will progress up to and beyond 90^{o}. This rotation is a big contributing factor to the speed of the ball on release.

5. Position of the arm at the end of the preparatory phase - elbow should be behind the head, the hand and wrist should be behind the elbow and the elbow should be level with or above the shoulder.

6. Arm action during the propulsive phase - this should be whiplike and not a lob or a push.

COMMON FAULTS

a) Wrong foot forwards - prevents hip rotation and limits shoulder rotation.

b) Arm position not behind the head - this may lead to a pushing or lobbing propulsive action and also limits the speed of movement of the arm.

c) Arm held too low - often found in combination with (a) and contributes towards similar results.

d) Forward arm action too slow - this may occur at an early stage of the development of the action. It will limit the distance which it is possible to achieve.

e) Propulsive arm action too fast - this will prevent the correct coordination of all the various lever actions.

SOME SUGGESTED ACTIVITIES FOR TEACHING THE THROW

These activities are based on the assumption that the children concerned are having difficulty with part or parts of the movement pattern. The activities focus on a part of the movement pattern and

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in doing the activity correctly the child will also perform the part of the movement pattern with which he or she is having difficulty.

The activities in the main employ an indirect teaching method and an example of this might be as follows.

> "We are going to have a relay race. Stand in lines facing the front at arms stretch distance from the persons in front and behind you. You must keep your left foot stationary at all times. The person at the back has a tennis ball which must be passed to the person at the front from hand to hand. No throwing is allowed and the left foot must remain still. Are you ready? Go!"

Now in order to carry out the above instructions the child in front of the one with the ball must step back with the right foot, turn to look for the ball held in the outstretched arm and reach backwards for it. He must then turn back towards the front, step forwards with his right foot and stretch his right arm forwards towards the child in front. Such a relay race can be great fun and young children usually enjoy such activities. Whilst doing this activity the child is in effect opening his shoulders from a closed stance and is adopting the correct preparatory position. As there is an obvious element of competition the actions will require to be done as quickly as possible and this should encourage the movement to be done as a continuous whole.

An example of direct teaching might be as follows.

> "A forward roll is done like this. Bend your knees, put your hands on the floor....."

In both examples the children are directed step by step. In the latter example they know what they are trying to achieve whereas in the first example they are having a race and hopefully achieving the real objective of the exercise as a by-product. The first example corresponds to activity one, in the next section.

In all of the activities a competitive element may be introduced. Initially it might be as well to omit this because it is important that the actions are done correctly. Two or three practice runs should achieve the correct action and then they can be speeded up and a race of some sort started. If however the action deteriorates under competitive pressure, as it may do, then a recap of the action should be carried out. Competition may be against the clock:- "How long does it take to throw thirty balls?" or "How many balls can you throw in 30 seconds?" or the competition may be against another team or individual:- "Who will throw the furthest?" or "Which team will finish first?" The type of competition may be varied which will help to maintain the children's interest.

SOME SUGGESTED TEACHING ACTIVITIES

Aim - to encourage opening of the shoulders from a closed stance and adopting of the correct preparatory position.

Activity 1 - Passing Relay

Method - relay teams of 4 or 5 in number, positioned at arms stretch distance, stand one behind the other. From this position the left foot (for right handed throwers) may not be moved. The person at the rear of the team has a tennis ball which must be passed, not thrown, to the front of the line. The front person then runs to the back and the passing is repeated and so on until the team has all its members back in their original positions.

This exercise requires a step backwards with a turn and a reach and then a step forwards with a turn and stretch. The amount of

reaching and stretching can be controlled by altering the distance between the team members. The anchoring of the front foot is important as this provides the pivot point for the turn. The following activities are also aimed at helping and improving the hip and shoulder rotation, important elements of the throw.

Activity 2 - Rapid-fire distance throws.

Method - in pairs at arms stretch distance, one behind the other. The rear partner has a supply of balls in any convenient container. Both partners must keep their front foot anchored. The front partner has to turn and reach for a ball then turn and throw it over a line a fixed distance away from him. The distance must not demand a maximum effort from anyone participating. This activity can be done with one partner doing all the throwing or the pair alternating every 5 or 10 throws. Initially this should be practised without emphasis on speed and then competition introduced in one of the forms suggested in the previous section.

Activity 3 - Rapid-fire target throws.

The organisation is as in activity (2) but instead of having to clear a line the ball has to hit a large unmissable target at a distance of 15-20 feet. This can be played as an individual or pair activity and can be non-competitive or competitive.

The target must be large enough or near enough to eliminate the need for great accuracy and enable the children to throw as rapidly as they can without worrying about missing. As proficiency increases the activity can be made more difficult by moving the target further away or by decreasing its size.

Organisational Comment

These activities may best be done when throwing towards a wall or fence in order to prevent the balls straying too far. The line in activity (2) could be the base of the wall itself and the targets could be chalked or painted on the wall or fence.

Activity 4 Box to box (in 3's)

From basic forward facing arms stretch distance stance the middle of the three, keeping front foot fixed turns and reaches for a ball from a box or suitable container or partners hand. He then turns and stretches and puts the ball into a box held at shoulder height by the third member of team. The positions of all three rotate and the winning group is the first one back to the original positions with all the balls in the rear box.

Activity 5 Bounce in hoop (in 3's)

The middle members of the three, using the basic stance, turns and reaches for a ball held by the partners behind him. He then turns and throws the ball into the hoop laid flat on the ground so that it bounces to the third member of the team, who attempts to catch it or collects it and puts it into a box. The positions then rotate until each partner has had a turn at throwing the balls. The distance between the thrower and the catcher can be adjusted to suit the proficiency of the thrower.

Activity 6

To encourage a harder throw the thrower in the above activity can be asked to bounce the ball so that it passes over a rope or low wall or some suitable object a short distance in front of him.

Comment

The activities outlined so far are aimed at producing the correct preparatory position. They should be putting the learner in an open stance with hips and shoulders turned away from the direction of the intended throw, and the arm extended behind the head. From this position the pupils must be encouraged to make the throw in one continuous movement without any hesitation. The child's throwing problem will not be helped if he stops or slows down halfway through the propulsive phase and settles down to his normal throwing position and movement pattern.

Aim:- to encourage the arm to be held high during the propulsive phase.

Activity 7

Method: a rope is suspended at shoulder height about 2' in front of the thrower who must throw the ball over the rope without either the ball or his arm touching the rope. A partner standing the other side of the rope should catch the ball and return it using a similar throw. The front foot must remain anchored during the throw but when catching the partner must be free to move and indeed will need to be further back from the rope.

Activity 8

Method: A line should be marked on a wall at approximately stretch height. The thrower should stand with the front foot fixed, just out of reach of the wall. The ball is thrown so that it hits the wall above the line and rebounds to a partner standing behind the thrower. The partner should stand quite close initially but as proficiency increases may move further away to encourage a harder throw.

Activity 9

As an alternative to using a partner in the above activity (8) a large cardboard box, basket or container of some kind could be used as a target, the aim being to rebound the ball from the wall above the line into the box.

Activity 10

The thrower stands under or just in front of a basketball or net-ball ring and from a fixed stance attempts to throw balls through the ring. A small group of pupils could all use the same ring simultaneously.

Activity 11

As an alternative to the previous activity (10) the pupils could attempt to throw the balls on to a sloping roof from a fixed stance close to the base of the wall.

Comment

Activities 7-11 are aimed at producing a high arm action during the propulsive phase. The line, rope or ring should be positioned sufficiently high and close enough to ensure that the correct response is elicited. If however the pupil is still unable to produce the correct movement pattern the following measure may be taken. It was stated in chapter one that the action of scratching the back of the neck or combing the back of the head requires the same shoulder joint positions as the starting position for an overarm throw. If then the pupil starts each throw holding the ball in contact with the back of the head or neck the throw will be starting with the arm in the correct position. If there is one fluid movement then the correct movement pattern should be performed.

Such a starting position could easily be utilised in some of the listed activities.

Conclusion

The activities set out above are not intended to remedy all of the listed common faults but have concentrated on obtaining the correct starting position and the correct arm action. The fault of having the wrong foot forward will be helped by these exercises but can also be aided by direct verbal encouragement. If coordination of the release of the ball at the correct point in the arm action is the problem then this may be helped by encouraging the other extreme. If for instance the child is releasing the ball too soon, so that it flies almost vertically upwards, he should be asked not to release it at the correct point of the arm swing but at a point which would under normal circumstances be too late. Similarly if the release is too late, with the ball being projected below the horizontal, the child should be encouraged to release at a point which would normally be much too early. The hope of such over compensation is that the child will perform somewhere between what is being asked for and what he is normally able to achieve thus getting reasonably close to the correct release point. If the child is having great difficulty with the release during the throw it may be best to go back to simple underarm throwing activities which also require the release mechanism to operate. If lots of practice of underarm activities produces some improvement then the overarm throw should be tried again. If the problem is not being solved then medical advice might be advisable.

The eleven listed activities are not intended to be a total programme but are put forward as examples of the type of activity which

might be used and the type of thinking behind them. All teachers have to be inventive and none more so than the teacher of physical education. Teachers must be constantly looking for new or different ways of making a point for a method which suits one child may not necessarily help another.

Although the manner of presentation of these activities has suggested a remedial situation it need not be limited to that. Far better to prevent than to have to cure and to this end some of the games could be used with infant or even nursery children. If the teachers of these young children are aware of what the children ought eventually to achieve in terms of the movement pattern then they can use some throwing activities. The games might need to be modified to suit the physical abilities of the children and should in any case be used sparingly. It would be wrong to force what for the majority will come naturally but a gentle nudge in the right direction will do no harm to the majority and may help to prevent some from experiencing difficulties later.

Appendix A

"Motor Achievement of Young Children"
M.V. Gutteridge, Archives of Psychology No. 244, May 1939.

The section of this paper on ball throwing is part of a much longer study which investigated and rated development in the following activities:

climbing	tricycling	throwing balls
jumping	hopping	bouncing balls
sliding	galloping	catching balls
	skipping	

In total 1,973 children of ages ranging from 3 to 7 were rated in the above activities using the following scale.

THE RATING SCALE

A KEY TO ESTIMATE DEGREE OF MOTOR SKILL

(Read key from bottom upwards)

	Old	New	
Skillful execution with variations in use	1	(D)	Uses skill in larger projects such as dramatic play.
	2	(C)	Speeds, races, or competes with self or others.
	3	(B)	Combines activity with other skill or skills.
	4	(A)	Tests skill by adding difficulties or taking chances.
Basic movements achieved	5	(10)	Evidence of accuracy, poise and grace.
	6	(9)	Easy performance with display of satisfaction.
	7	(8)	Movements coordinated.
Habit in process of formation	8	(7)	In process of refining movements.
	9	(6)	Is practicing basic movements.
	10	(5)	Is progressing but is still using unnecessary movements.
	11	(4)	Tries even when not helped or supported, but is inadept.
	12	(3)	Attempts activity but seeks help or support.
No attempt made	13	(2)	Makes no approach or attempt but does not withdraw.
	14	(1)	Withdraws or retreats when opportunity is given.

Key used in rating the following activities:

Climbing	Tricycling	Throwing balls
Jumping	Hopping	Bouncing balls
Sliding	Galloping	Catching balls
	Skipping	

NOTE: After the commencement of the study, the numbers 1-14 were found to be cumbersome and to include items which were dissimilar. It was therefore decided to adopt the new rating as is seen in the right hand column.

DEFINITION OF STEPS IN KEY TO ESTIMATE MOTOR SKILL

No Attempt Made

1. Withdraws or retreats when opportunity is given - appears afraid of making actual attempt to perform activity - shows definite unwillingness to make effort - signs of hesitancy in new situation.

2. Makes no approach nor attempt but does not withdraw - although showing no outward sign of fear or hesitancy exhibits no interest even when confronted with opportunity - makes no effort at all to seek out or to venture into new activity.

Habit in Process of Formation

3. Attempts activity but seeks help or support - makes movements indicative of willingness to participate in activity, to use tool, try toy or equipment but seeks support and needs encouragement to make any advance.

4. Tries even when not helped or supported, but is inept - makes decided attempts without help or support to try out the tool, toy, or equipment and to master the technique - but is clumsy - movements are uncoordinated.

5. Is progressing but is still using unnecessary movements - makes more useful effort but still movements are exaggerated and involve the use unnecessary muscles and parts of the body not directly concerned with the basic movements of the skill.

6. Is practising basic movements - practice is concentrated on learning the basic movements through repetition of the gross performance though certain crudities are apparent and no obvious effort is directed toward refining.

7. In process of refining movements - the basic movements are now more definite and selected but still need further refining - practice is having the effect of furthering precision.

Basic Habit Achieved

8. Movements coordinated - elimination of unnecessary movements - actions now show controlled use of selected muscles - precision in action and good direction of effort.

9. Easy performance with display of satisfaction - with such co-ordination of muscles child is able to achieve results - shows definite satisfaction in bodily skill and power over material.

10. Evidence of accuracy, poise, and grace - gives appearance of effortless skill without apparent conscious attention to component movements - as a result of refinement of movements and adjustment to requirements shows ease, grace and poise in bodily action.

Skillful Execution with Variations in Use

A. Tests skill by adding difficulties or taking chances - having achieved the basic movements and displaying excellent performance, he adds difficulties, obstacles or hazards that in effect offer a further test of his skill.

B. Combines with other skill or skills - combines basic activity with another skill or motor activity.

C. Speeds, races, or competes with self or others - definitely appears to match his skill with that of others or to be competing with his own record - element of competition is added now that attention is no longer needed to learn basic skill.

D. Uses skill in larger projects, such as dramatic play - particular motor activity used as incidental to or in association with a larger project, including dramatic play. Primary emphasis is not on the execution of the skill for its own sake.

Using the rating scale and detailed definition of the steps in the key the data was collected by the teachers of the children participating in the study. The comprehensive data sheet used is shown here.

Conclusions drawn from the data indicate:-

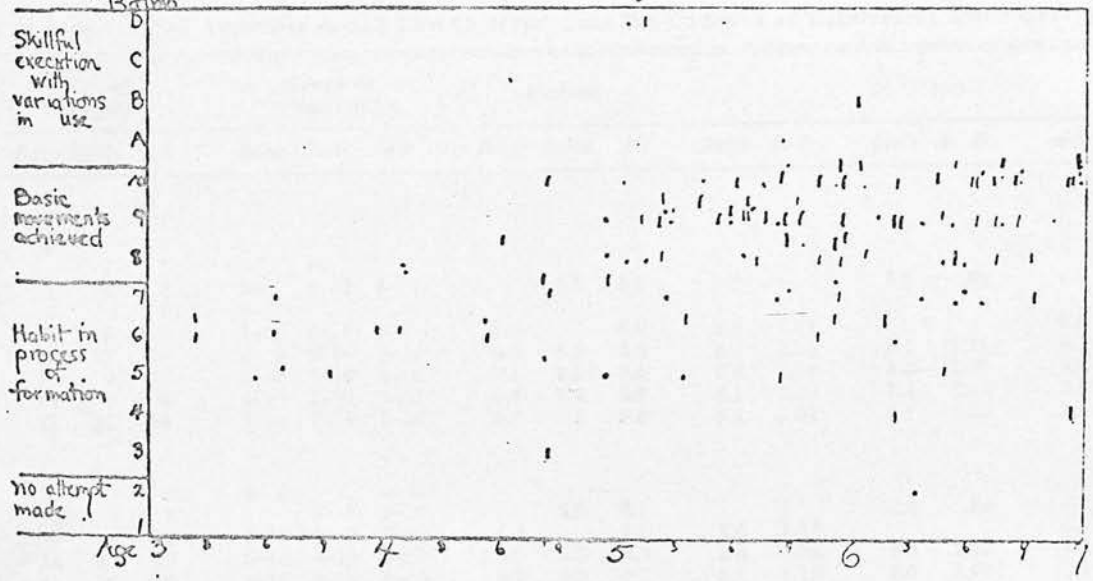
i) that at any age there is a wide variety of achievement in any of the activities.

ii) There is a difference in the age of entry of each type of activity into the motor repetoire of the children.

iii) Each activity has a period of rapid increase in achievement followed by a slowing down when mastery of the basic movements has been established. This slowing down of the median curve of achievement could be attributed not so much to the completeness of motor development as to the lack of environmental stimulation and challenge to further effort. The study does not attempt to explain the cases where retardation of achievement was observed but suggest further investigation to ascertain whether such cases are due to retarded physical development or lack of opportunity suited to the individuals needs.

XIII THROWING BALLS

Scattergram showing distribution of cases according to age and skill of 113 children



median rating for half group at each three months	A			7.0	8.5	8.0	9.0	8.5	9.0	9.5	9.5	9.0
	B	5.0			8.6	9.6	9.3	8.5	8.0	6.5	9.3	
median rating for total group at each three months		5.5		6.5	7.0	8.7	9.2	9.5	8.7	8.8	8.5	9.6	9.5

Key
1 Boys
• Girls

TABLE IX

RATINGS IN *Throwing Ball* ACTIVITIES OF 113 TWO TO SEVEN YEAR OLD CHILDREN AT HALF-YEARLY AND YEARLY AGE LEVELS

Age in Months	*No. of Subjects*			*Range in Ratings*			*Median*			*Mean*						*Percent Rating 8 or better*
	Boys	*Girls*	*All*	*Boys*	*Girls*	*All*	*Boys*	*Girls*	*All*	*Boys*	*S. D.*	*Girls*	*S. D.*	*All*	*S. D.*	
Half-yearly																
24–29	1		1	4–												
30–35	1		1	6–												
36–41		1	1		6–											
42–47	1	4	5	5–	5– 7	5– 7		5.8	5.6			5.8	.65	5.6	.08	
48–53	2		2	6–												
54–59	6	2	8	3–10	5– 6	3–10	7.5		6.8	6.8	2.11			6.5	1.94	25
60–65	7	12	19	6– 9	5–10	5–10	9.0	8.9	8.8	8.1	1.13	8.1	1.61	8.1	1.45	74
66–71	17	9	26	5–10	7–10	5–10	9.4	8.0	9.3	8.6	1.28	8.6	1.07	8.6	1.22	85
72–77	18	8	26	4–10	2–10	2–10	8.8	7.8	8.7	8.1	1.80	7.4	2.45	7.9	2.05	65
78–83	13	11	24	7–10	7–10	7–10	9.7	9.3	9.8	9.1	1.01	8.7	1.30	8.9	1.18	83
Yearly																
24–35	2		2	4– 6		4– 6										
36–47	1	5	6		5– 7	5– 7		6.0	6.0			5.8	.84	5.7	.91	0
48–59	8	2	10	3–10	5– 6	3–10	6.3		7.0	6.6	1.87			6.4	1.74	20
60–71	24	21	45	5–10	5–10	5–10	9.5	9.0	9.2	8.5	1.78	8.3	1.49	8.3	1.40	80
72–83	31	19	50	4–10	2–10	2–10	9.1	9.0	9.3	8.5	2.10	8.2	1.96	8.4	1.74	74

Data related to throwing balls

In this section of the study 113 children were used, 66 boys and 47 girls ranging from 2-7 years old. The data is shown on a scatter diagram and a table.

Scatter Diagram VIII shows distribution of cases according to age and skill of each child and median scores for each three months period.

Table IX shows number of boys and girls at each half yearly and yearly age level. It also shows range of ratings, mean and median ratings, and percentage that are proficient, in throwing balls, for each age group.

QUANTITATIVE ANALYSIS OF DATA

Proficiency in ball throwing at each age

One child of six years is recorded as refusing to throw a ball (Rating 2); a few at each age are said to use unnecessary movements in throwing (Rating 4). 14 percent of the whole number are said to be practising ball throwing (Ratings 6 and 7). In year two and three, no child is rated as being able to throw well, at four, one child only is rated as skillful (Rating 10). In the period from five years to five years six months, 74 percent are rated as throwing well, while in the second part of that period, 85 percent are proficient. In the period from six years to six years six months, 65 percent can throw well and 83 percent at the latter half of the year.

Median ratings in each age group

The median at three years six months is at point 5.6 on the scale, which denotes awkwardness. The median rises, however, during year four, to point 6.8 which indicates "practising" and then rises steeply to point 9.3 at five years and six months. There is a slight fall at six years when the median drops to 8.7 but at six years six months it has reached 9.8.

The range of ratings in each age group

The range in ratings at any six months period is very striking. In most periods the scores show some who either refuse to throw (Rating 2) or are awkward (Ratings 3 to 4) as well as some who are proficient (Rating 10). In year four the range is from 3, which denotes the need of help to point 10, the highest point on the scale. In year five the range is from a rating of 5, for awkward throwing, to a rating of 10 and at six years a range from a refusal (Rating 2) again to 10, the highest point on the scale.

Comparison of the ratings of boys and girls

A comparison of the median achievement of the boys and girls in throwing shows that the boys are ahead in each age group. In the half year from six years to six years six months, they are as much ahead as one point on the scale.

A comparison of the range of ratings shows that the boys have a wider range at year four, (6 points), the girls at year six (2 points), while at year five the range is identical for both sexes.

The size of the ball may somewhat change his method of handling it and the distance it travels after leaving his hands. His success will have to be judged by his method of throwing and the length of his throw.

Balls of four and five inches in diameter. Twenty-four children of five years when throwing a ball of this size, show that three are rated as awkward (Rating 4), or as practising (Rating 6), but twenty-one throw well (Rating 8-10). Twenty-nine of six years show that four are rated low (Rating 4, 5), but that there are twenty-five who are skillful in throwing a ball of this size (Rating 8-10).

> Frederick (6: 3) threw the ball (5 in.) to Eugene. The ball did not even go in that direction, owing to his poor muscular control. His movements were awkward. (rated 4)
>
> Georgina (6 : 4) threw the ball to Lorraine using both hands in an upward swinging movement. Her movements were not very good. At first she threw it too far and didn't seem to be able to control her movements, the second time she did better, and Lorraine caught it. She threw it 75 inches. (rated 7)
>
> Mitzi (5: 5) threw the ball gracefully, swinging her body in a perfectly poised rhythm, Mary caught it. She threw it 41 inches. Mitzi's movements were coordinated and it seemed no effort. She enjoyed the activity. (rated 10)

Methods of throwing a ball. (1) the earliest method of throwing a ball seems to include mass movements of all the body. The child stoops, straightens, heaves with his whole body and releases the ball with much expenditure of energy and little force. His direction is poor. (2) The movements become more specialized and he throws with less movement of his whole body and more use of his arms. His direction and the force of his throw are improving. He still uses both hands even for a small ball. (3) He begins to throw "cleanly" using only the muscle groups that are necessary for launching a ball. He now uses one hand for smaller balls. The following extracts from the records will illustrate these three stages.

> Throwing 6 inch ball, uses both hands. Holds ball at full length of arms over head. Throws with full force, using all body. (rated 5)
>
> ... threw the ball (diam. 6 inches) with body hands with upward swinging movement. He found it difficult. (rated 6)
>
> ... threw the ball (6 in. diam.) with his right hand. He did it easily and with good muscular control. (rated 8)

Appendix B

Motor Development of throwing summarized from Gesells and Ilg.

Child sitting

40 weeks - either retains hold on the ball or releases it without reference to target (examiner in this case).

48 weeks - rolls or throws the ball - about half may project it towards examiner.

52 weeks - over half definitely throw the ball.

56 weeks - over half repeatedly toss or roll the ball to examiner on request.

1 year - shows variety of throwing actions:- rolling, tossing sidearm/underarm/overarm. Inability to time release means course of ball is inaccurate. The throwing action is confined almost entirely to the arm with the shoulder playing the major roll and wrist and elbow displaying little mobility.

Child standing

18 months - the ability to release is not yet incorporated into movements of tossing and throwing and exaggerated finger extension and inadequate timing cause the ball to be poorly directed. The child now tends to walk forward before and after the cast which consists of a forward thrust of the arm. If not allowed to walk the child stands with feet together, there is no rotation but may lean forward from the hips.

2 years - very similar posture to above with steps before and after delivery. There may be slight rotation with a standing throw. Although release timing has improved, exaggerated extension of the fingers still causes poor direction control.

Two-and-a-half-years:

Is uncertain as to stance, showing great variations
Stands still, skips or runs with ball
Stands erect or crouches
Tosses or throws
Usually maintains weight on right foot
Directs ball poorly
Throws ball about five to seven feet
Throws a bean bag into a twelve-inch hole at a distance of three feet
Throws a large ball (diameter 5.2 inches) from three to five feet.

Three-and-a-half-years:

Has difficulty in acquiring preferred stance; hesitates before throwing
Faces straight ahead, neither foot in advance
Leans slightly toward left
Extends trunk in bringing ball above shoulder
Rotates with throw, by stepping or by sliding one foot ahead
Throws mostly with shoulder and elbow
Shows improvement in wrist movement and timing of release
Uses fingers to guide course of ball
Boys are superior to girls in ease of delivery and accuracy of direction

Four years:

Has acquired definite stance for delivery
Stands facing forward, neither foot in advance
Shifts weight to right foot preparatory to throwing
Leans forward and rotates body to left on throw
Usually uses right foot as fulcrum for the delivery
May shift his weight to left foot, or draw it back, or slide right foot forward
Throws ball straight ahead but with poor control of its height (inadequate timing of release)
Demonstrates a preferred hand in throwing by greater frequency in its use, greater accuracy and distance of throw, and better neuro-motor coordination in stance and delivery
Boys throw ball with horizontal motion from above or to right of shoulder
Girls throw ball from above shoulder with downward sweep

Five years:

Boys

Stance:
Advance left foot
Draws arm obliquely up to position in shoulder axis
Rotates shoulder markedly, twisting and leaning to the right
Lowers right shoulder, frequently crouches forward
Shifts weight to right foot and extends left arm out laterally

Delivery:
Throws ball with horizontal motion around advancing shoulder at about shoulder level
Accelerates extension of elbow and wrist just previous to release
Releases ball when arm is fully extended
After release arm sweeps across front of body
Rotates and twists body toward left, raising right shoulder, then bends forward at hips and leans toward the left.
Shifts weight to left foot, raising right heel and rotating it outward
Shoulder, elbow, wrist and fingers well coordinated
Legs function inadequately
Throws a baseball a distance of abouttwenty-four feet

Girls

Stance:

Appears uncertain as to stance
Usually advances neither foot
Supports weight sometimes on right foot, sometimes on left
Draws arm obliquely up to over shoulder to a position back of shoulder or head, with elbow high at side.
Extends trunk, lowers head, rotates and twists toward the right.

Delivery:

Throws ball with forward and downward movement of hand, with forward and medial movement of elbow
Holds wrist in dorsal flexion and then suddenly flexes it volarly and extends the fingers to release the ball
Sweeps hand to left and downward after release
Rotates and extends body, raises head, and then flexes forward at the hips and twists to the left.
Shifts weight to left foot or steps forward on right foot
Throws ball principally with shoulder and wrist movement
Trunk and legs, particularly the latter, function inadequately
Throws a baseball a distance of about fifteen feet

Six years:

Boys

Stance:

Advances left foot markedly
Draws hand obliquely up to position at side and back of right shoulder joint
Rotates and twists body, and leans markedly to the right
Extends trunk and shifts weight to right foot
Flexes knees and raises extended left arm high at side

Delivery:

Throws ball as at 5 years
Moves body and throwing arm forward markedly, with great acceleration of arm movement and pronounced shifting of weight to the left foot
Steps forward with left foot at start of delivery, or slides right foot ahead as ball is released.
Makes optimal use of shoulder, elbow, wrist and trunk, and in some cases of the legs.

Girls

Stance:

Differs from that of 5-year-old girls mainly in that in all cases the weight is shifted to the right foot
Holds ball in varying positions back of shoulder or in shoulder axis.

Delivery:

Shows improvement over 5-year-old girls in the greater excursion of the arm and greater forward flexion at the hips. Steps forward with left foot before throwing in some instances.

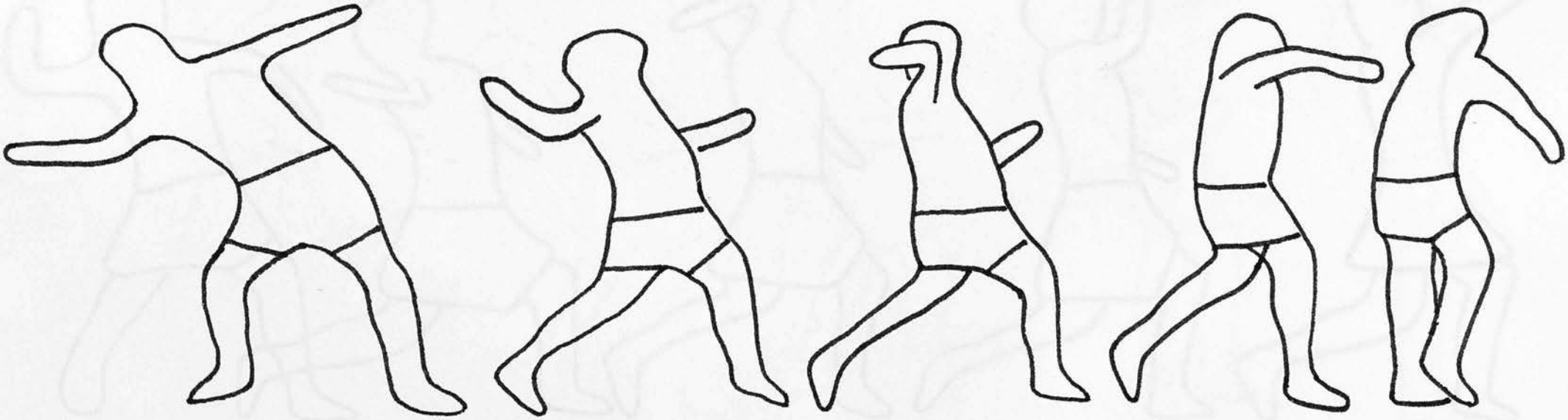
Sex differences. Sex differences at 5 years and 6 years were clearly evidenced both in the throwing stance and in the actual delivery of the ball. Among the outstanding differences were the following: (1) Boys advanced the left foot only during the delivery. (2) Boys held the ball at the right of the shoulder, while girls in general held it above the shoulder. (3) Boys utilized trunk and leg movements to greater advantage than did girls. Girls stood more erect in throwing than did boys. (4) Boys used the left arm to greater advantage in maintaining balance. (5) Boys shifted their weight more markedly than did girls. (6) Boys directed the course of the ball more accurately than did girls. On release boys held the wrist and fingers in almost a straight line with the forearm, whereas girls flexed the wrist sharply so that the hand was brought down almost at a right angle with the forearm.

Appendix C

The first two tracings are good throws, a male and a female, and the second two show poor throw, a female and a male. There is a marked similarity between the first two, both exhibiting a high whip-like arm action, a positive weight transfer and a good range of rotation of hips and shoulders. Tracing III, a poor male thrower, shows a good starting position and high arm action but limited forward rotation caused by no real weight transfer. Tracing IV, a poor female thrower, shows limited rotation and a low arm action which is a push.

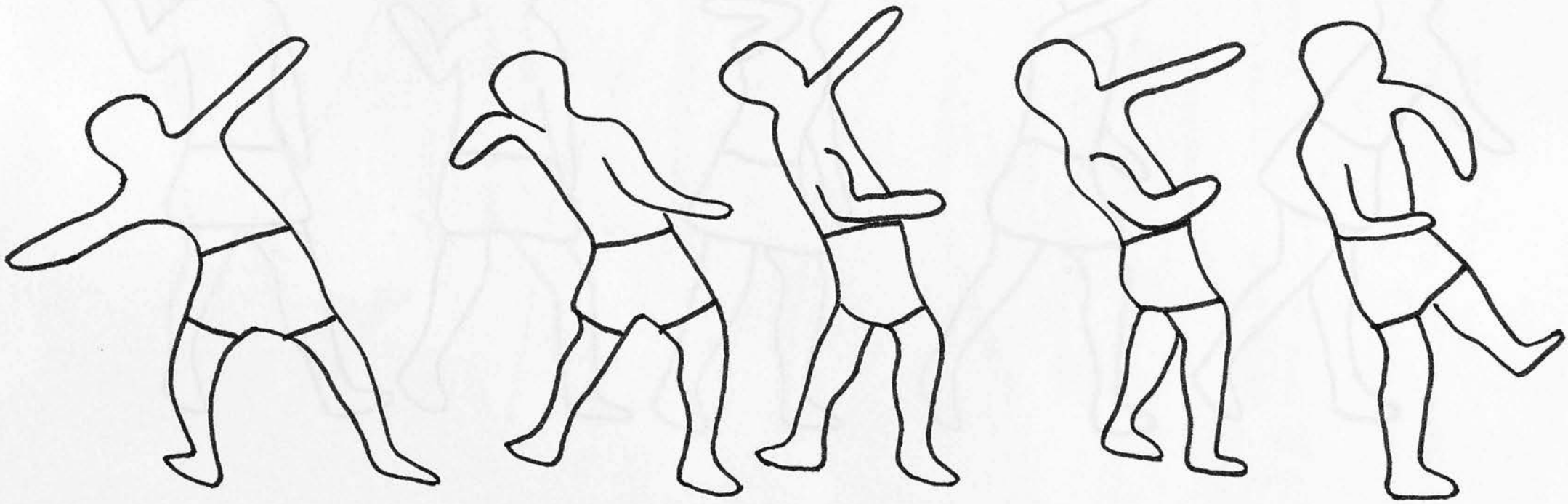
The two line tracings are of one of the children who was video taped at the very start of the project. Her action was quite immature and inconsistent. This is typified by her readiness to throw off either foot.

Tracing I - male, good thrower

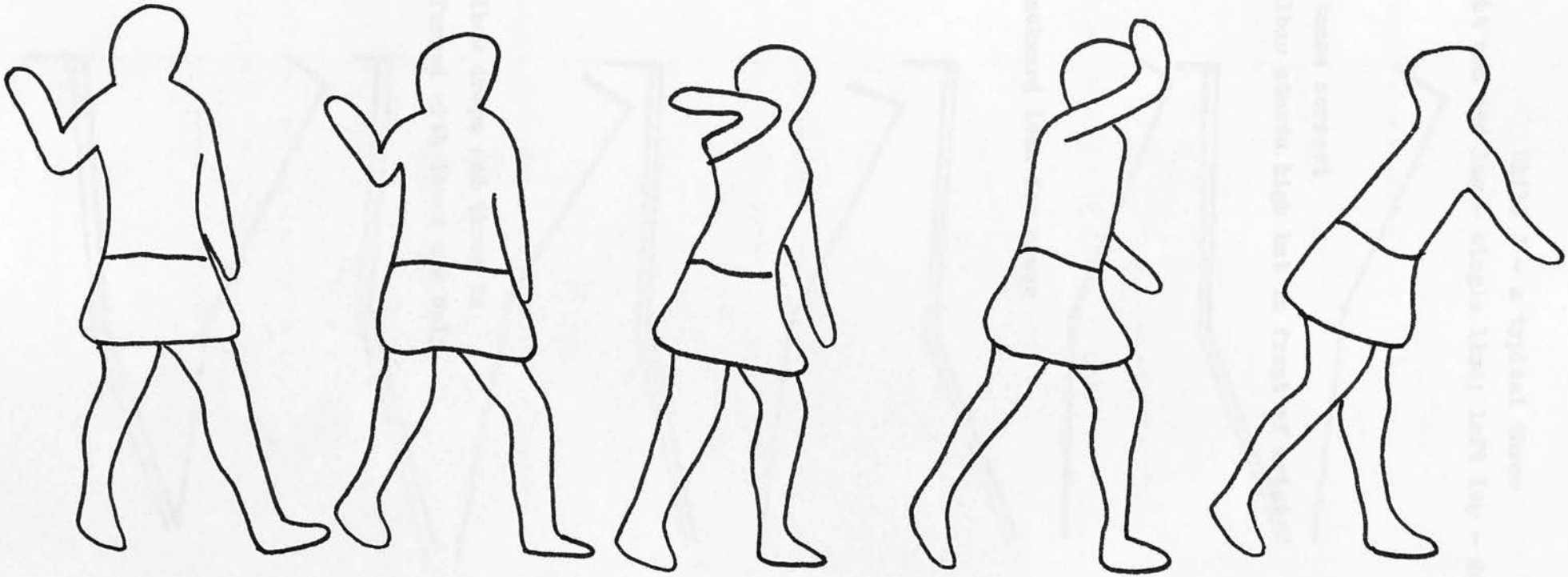


Tracing II - female, good thrower.

Tracing III - male, poor thrower.

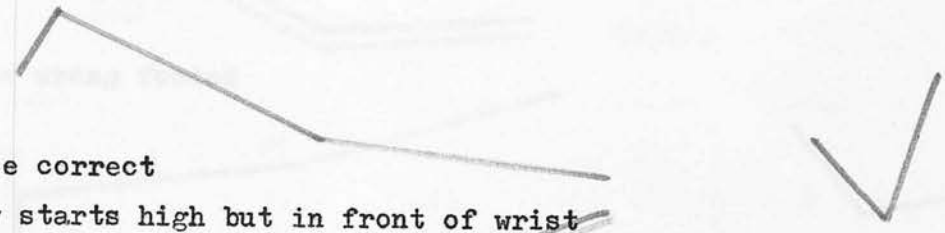


Tracing IV - female, poor thrower.

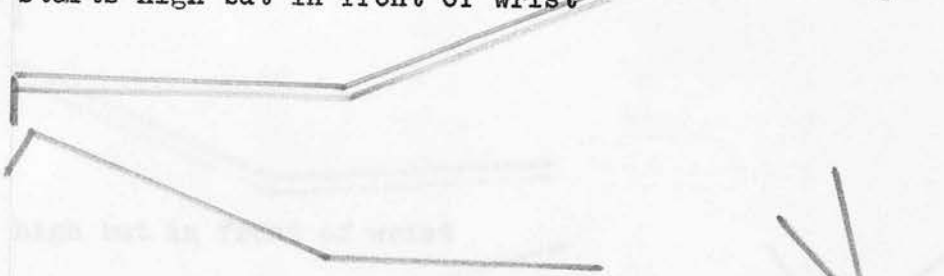


Child J - a typical throw

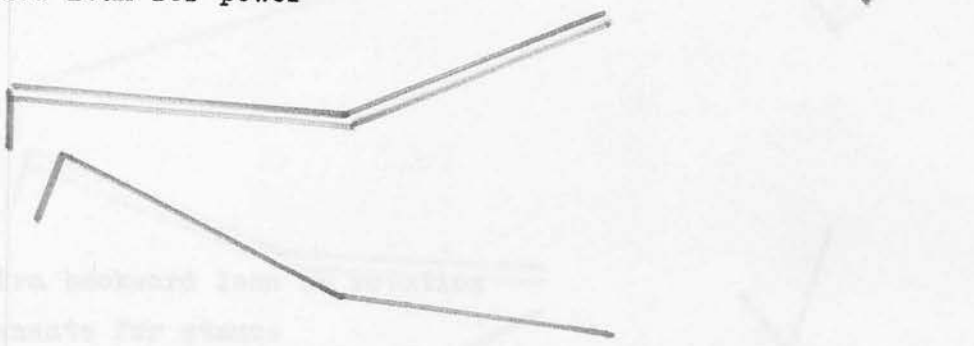
Right arm and leg - single line; left leg - double line



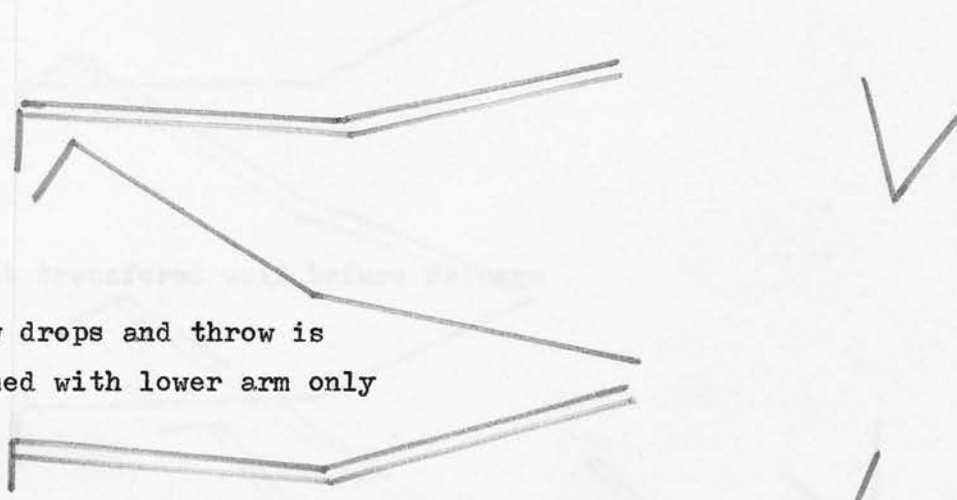
- stance correct
- elbow starts high but in front of wrist



- backward lean for power

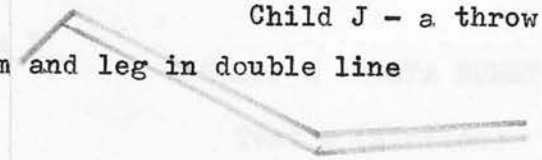


- elbow drops and throw is performed with lower arm only



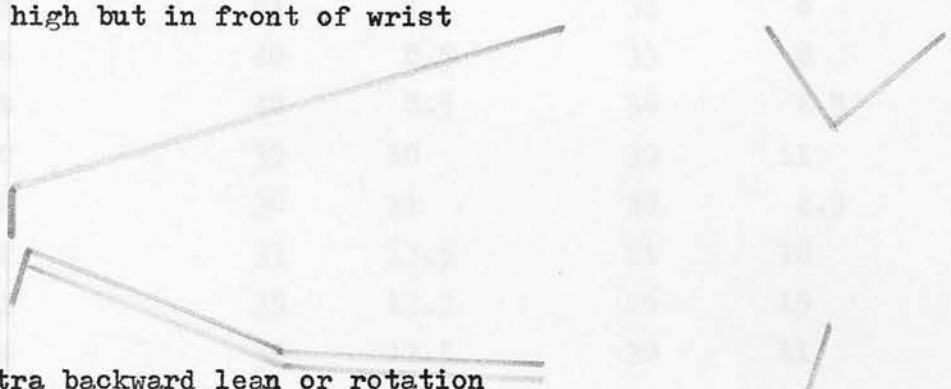
Child J - a throw from incorrect stance

Left arm and leg in double line

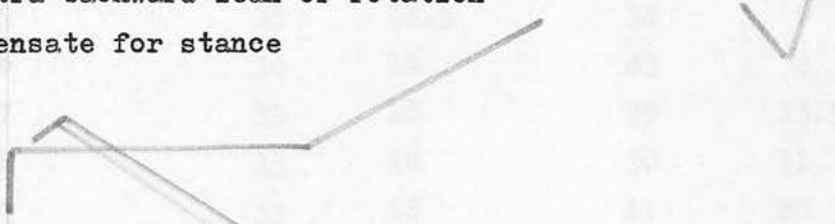


- stance wrong footed

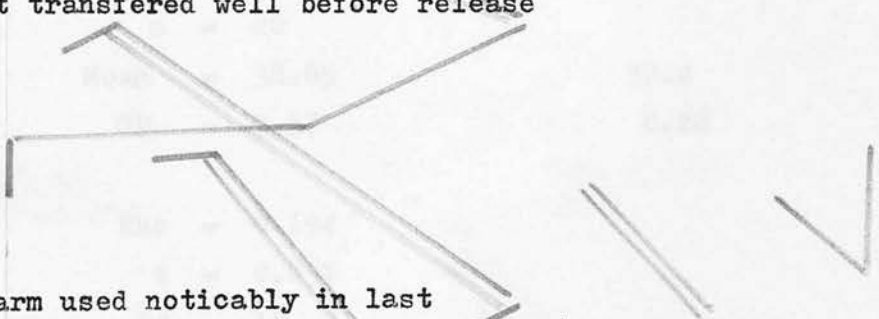
- elbow high but in front of wrist



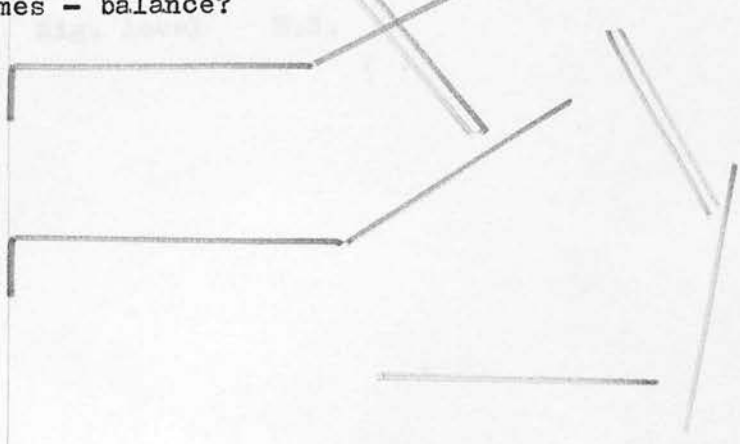
- no extra backward lean or rotation to compensate for stance



- weight transfered well before release



- left arm used noticably in last two frames - balance?



Appendix D

GROUP I DATA SHEET I

	Test D (Airflow)		Test A	
subject	feet	rank	score	rank
1	46	1	41	3
2	45	2.5	24	16
3	45	2.5	20	19
4	44	4	46	1
5	43	5	23	17
6	42	6	33	8
7	41	7	33	8
8	40	8.5	33	8
9	40	8.5	36	4.5
10	39	10	30	11
11	36	11	36	4.5
12	35	13.5	21	18
13	35	13.5	26	15
14	35	13.5	30	11
15	35	13.5	34	6
16	34	16	43	2
17	33	18	29	13.5
18	33	18	30	11
19	33	18	11	20
20	27	20	29	13.5
n =	20			
Mean =	38.05		30.4	
SD =	5.17		8.28	
Rho =	0.194			
t =	0.837			
df	18			
Sig. level	N.S.			

GROUP I DATA SHEET II

	Test D (Tennis)		Test D (Airflow)	
subject	feet	rank	feet	rank
1	109	1	43	4
2	97	2	35	13
3	87	3	41	6
4	84	4.5	45	2
5	84	4.5	46	1
6	81	6	44	3
7	79	7	42	5
8	74	8	40	7.5
9	70	9	40	7.5
10	63	10	39	9
11	62	11.5	36	10
12	62	11.5	33	15.5
13	60	13.5	27	17
14	60	13.5	33	15.5
15	59	15	35	13
16	57	16	34	14
17	42	17	35	13
n =	17			
Mean =	72.35		38.11	
SD =	16.78		5.15	
Rho =	0.723			
t =	4.06			
df	15			
Sig level	0.001			

GROUP I DATA SHEET III

subject	Test D (Tennis) feet	rank	Test D (Airflow) feet	rank
1	140	1	51	1
2	113	2	27	19
3	107	3	45	2
4	97	4	43	3.5
5	95	5	42	7
6	94	6	42	7
7	87	7	43	3.5
8	85	8	39	8.5
9	81	9	42	7
10	76	10	39	8.5
11	73	11	33	15
12	68	12	36	12.5
13	66	13	35	14
14	65	14	36	12.5
15	64	15.5	37	10.5
16	64	15.5	30	17
17	62	17	37	10.5
18	53	18	28	18
19	51	19	32	16

n =	19	
Mean =	81.1	37.73
SD =	22.6	6.15

Rho =	0.637
t =	3.4
df	17
Sig. level	0.01

GROUP I DATA SHEET IV

	Test D (Airflow)		Form	
subject	feet	rank	mark/10	rank
1	35	13.5	8	8.5
2	44	4	10	2.5
3	46	1	8	8.5
4	40	8.5	10	2.5
5	27	20	7	13
6	45	2.5	10	2.5
7	33	18	3	20
8	40	8.5	7	13
9	35	13.5	5	17
10	41	7	10	2.5
11	33	18	4	18.5
12	45	2.5	8	8.5
13	42	6	8	8.5
14	39	10	9	5
15	36	11	4	18.5
16	35	13.5	8	8.5
17	35	13.5	6	15.5
18	33	18	7	13
19	34	16	6	15.5
20	43	5	8	8.5

n = 20

Rho = 0.687

t = 4.01

df 18

Sig. level 0.001

GROUP I DATA SHEET V

subject	Test A score	rank	Form mark/10	rank
1	34	6	8	6
2	46	1	4	18.5
3	41	3	5	15
4	36	4.5	10	1
5	29	13.5	8	6
6	20	19	9	2
7	30	11	4	18.5
8	33	8	6	12
9	30	11	7	10
10	33	8	8	6
11	11	20	5	15
12	24	16	8	6
13	33	8	8	6
14	30	11	8	6
15	36	4.5	4	18.5
16	21	18	5	15
17	26	15	4	18.5
18	29	13.5	6	12
19	43	2	6	12
20	23	17	8	6

n = 20

Rho = - 0.112

t = - 0.479

df 18

Sig. level NS

GROUP I DATA SHEET VI

subject	Test D (Airflow) feet	rank	Retest D (Airflow) feet	rank
1	46	1	42	5
2	45	2.5	43	3
345	45	2.5	27	17
4	44	4	42	5
5	43	5	51	1
6	42	6	42	5
7	41	7	45	2
8	39	8	39	7.5
9	36	9	37	9.5
10	35	11.5	39	7.5
11	35	11.5	36	11.5
12	35	11.5	33	14
13	35	11.5	37	9.5
14	34	14	35	13
15	33	15.5	36	11.5
16	33	15.5	32	15
17	27	17	28	16

n = 17
Rho = 0.614
t = 3.01
df 15
Sig. level 0.01

GROUP I DATA SHEET VII

subject	Test D (Tennis) feet	rank	Retest D (Tennis) feet	rank
1	109	1	140	1
2	97	2	85	6
3	87	3	107	2
4	84	4.5	87	5
5	84	4.5	94	4
6	81	6	95	3
7	79	7	81	7
8	63	8	76	8
9	62	9.5	62	14
10	62	9.5	68	9
11	60	11	53	15
12	59	12	64	12.5
13	57	13	66	10
14	51	14	64	12.5
15	42	15	65	11

n	=	15
Rho	=	0.838
t	=	5.54
df		13
Sig. level		0.001

GROUPII DATA SHEET I

subject	Test D (Tennis) feet	rank	Test D (Airflow) feet	rank
1	128	1	74	1
2	121	2.5	53	1o.5
3	121	2.5	66	2.5
4	119	4.5	61	6
5	119	4.5	60	7.5
6	112	6.5	60	7.5
7	112	6.5	66	2.5
8	106	8	63	4
9	103	9	49	13
10	101	10.5	56	9
11	101	10.5	62	5
12	98	12	53	10.5
13	97	13	51	12
14	86	14	36	19
15	84	15	43	14
16	82	16	42	15.5
17	75	17	42	15.5
18	71	18	38	18
19	50	19	41	17
20	43	20	32	20

n	= 20	
Mean	= 96.45	52.4
SD	= 23.48	11.66

Rho	= 0.855
t	= 7.00
df	18
Sig. level	0.001

GROUP III DATA SHEET I

subject	Test D (Airflow) feet	rank	Test A score	rank
1	61	1	41	4
2	53	3.5	51	1.5
3	53	3.5	22	6
4	51	5	24	5
5	39	6	46	3
6	54	2	51	1.5

n	=	6	
Mean	=	51.8	39.16
SD	=	7.16	13.07
Rho	=	0.185	
t	=	0.378	
df		4	
Sig.level		NS	

GROUP III DATA SHEET II

subject	Form mark/10	rank	Test D (Airflow) feet	rank
1	8	1	61	1
2	6	3	53	2.5
3	7	2	53	2.5
4	4	4.5	51	4
5	4	4.5	39	5
n =	5			
Mean =	5.8		51.4	

Rho = 0.95
t = 5.26
df 3
Sig. level 0.02

GROUP III DATA SHEET III

subject	Form mark/10	rank	Test A score	rank
1	10	1	41	3
2	6	4	51	1
3	8	2	22	5
4	4	5	24	4
5	7	3	46	2
n =	5			
Mean =	7		36.8	

Rho = -0.2
t = -0.35
df 3
Sig. level NS

GROUP LV DATA SHEET I

subject	Test D (Tennis) feet	rank	Test D (Airflow) feet	rank
1	176	1	59	8.5
2	168	2	63	3
3	167	3	60	6
4	165	4	61	4
5	163	5	64	1.5
6	155	6	57	10.5
7	150	7	60	6
8	149	8	59	8.5
9	148	9	60	6
10	145	10	64	1.5
11	140	11	56	13
12	130	12	50	19
13	127	13	56	13
14	126	14	57	10.5
15	124	15	54	15
16	120	16	53	16
17	115	17	51	18
18	113	18	56	13
19	112	19	52	17
20	101	20	44	20

n	= 20	
Mean	= 139.7	56.8
SD	= 22.04	5.08
Rho	= 0.792	
t	= 5.5	
df	18	
Sig. level	0.001	

GROUP IV DATA SHEET II

subject	Form mark/10	rank	Test D (Tennis) feet	rank
1	10	3	176	1
2	10	3	168	2
3	9	9.5	167	3
4	10	3	165	4
5	9	9.5	163	5
6	9	9.5	155	6
7	9	9.5	150	7
8	8.5	14.5	149	8
9	7.5	18	148	9
10	8	16	145	10.5
11	9	9.5	145	10.5
12	9	9.5	140	12
13	7	21	137	13
14	9	9.5	130	14
15	10	3	127	15
16	7	21	126	16
17	10	3	124	17
18	9	9.5	120	18
19	7.5	18	115	19
20	7	21	113	20
21	8.5	14.5	112	21
22	7.5	18	101	22

n = 22
Mean = 8.6
SD = 1.03

Rho = 0.53
t = 2.8
df 20
Sig. level 0.02

Appendix E

Electronic equipment used:-

Camera - J.V.C. Nivico Portable video camera GS-4500

Recorder - J.V.C. Nivico Portable video tape recorder PV-4500

Both of the above items are manufactured by -

Victor Company of Japan Ltd.,

Tokyo, Japan.

Tape - $\frac{1}{2}$" Scotch Video Tape

Monitors - Ultra (model no. 6818), Battery-Mains Portable Receiver.

- Hitachi (model no. MVIE),"Memory Vision."

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